Study regarding the state of the Black Sea for the project *Innovative techniques and methods for reducing the marine litter in the Black sea coastal areas*-RedMarLitter BSB552

"This material has been produced with the financial assistance of the European Union. The contents of this publication are the sole responsibility of<S.C. ATLAS RESEARCH S.R.L.> and can in no way be taken to reflect the views of the European Union"

Contents

Short presentation

The RedMarLitter project aims to develop innovative techniques and methods for reducing marine litter in the Black Sea coastal areas, by protecting the cleanliness of the sea and its coast through monitoring actions like analyzing the load, track main polluting streams and clean up the waste in specific vulnerable areas. The project focuses also on the cross-border cooperation of Romania and Bulgaria (the only one EU Member States in the Black Sea Basin).

The project also aims to consolidate the cross-border cooperation and exchange of information between Romania and Bulgaria on issues related to the maritime area; to establish the vision and strategic goals for the Black Sea area relevant in reducing river and marine litter; to contribute to a wider dissemination by promoting the available information on marine litter and the best practices to all stakeholders of the Black Sea Basin. The information will be held in a common database, with the task of identifying the path of major waste streams, linking them to air and sea currents, and locating potential concentration points. This report is a main result of the work package as well as the entire RedMarLitter project. The content is comprise of two part: the first one refers to the data on water flows and related waste streams in the Black Sea, the second part study's the current state of a selected area of the Black Sea and the types and distribution of waste in it, contributing to a comprehensive description of current existing conditions of the maritime areas. Generally, this document has to be considered as "in progress document", which aims at the definition of the existing conditions and dynamics of Romanian and Bulgarian maritime litter. In particular, in the short term the goal of the review is to support the identification of issues by a transboundary approach. To promote marine litter collection in the Black Sea and its coastal areas, some cross-border cleaning campaigns will be organized, alongside with recommendations and the lessons learned.

Research methodology

In order to carry out this study, data were collected on the possible sources of pollution, inventory and analysis of existing conditions, existing maps, identified natural valuable areas, spatial representation of current flows, and current profiles. During first meetings with all specialists it was established that the available information on the accumulated quantity of waste will be collected and analyzed. A common database will be created and the degree of contamination will be assessed. It has been scientifically proven that accumulated amounts of waste are transported along by rivers.

The data were obtained from several free Romanian sources, through official requests to different institutions that owned them (National Marine Institute for Research and Development, Maritime Hydrographic Directorate, Mare Nostrum, "Romanian Waters" National Administration, and Maritime Ports Administration).

In order to simulate different parameters on the surface of the sea (e.g. sea currents, water temperature or salinity) and to simulate the trajectories of objects for different situations, two numerical models have been used (MOHID "MOdelo HIDrodinamico" and POM "Princeton Ocean Model"). In order to transpose the data into GIS format, the ArcMAP software was used.

1. Part One - Providing data on water flows and related waste streams in the Black Sea (Romanian aquatorium)

1.1. Introduction

Since ancient times, the western shore of the Black Sea and Danube mouths have been thoroughly researched, at the specific knowledge level of that time. Research on the variability of Black Sea currents, especially in the area of the Danube's mouths, began in 1857, following the formation of the European Danube Commission, with the aim of improving maritime navigation. From these observations the north-south current along the coast is noticed.

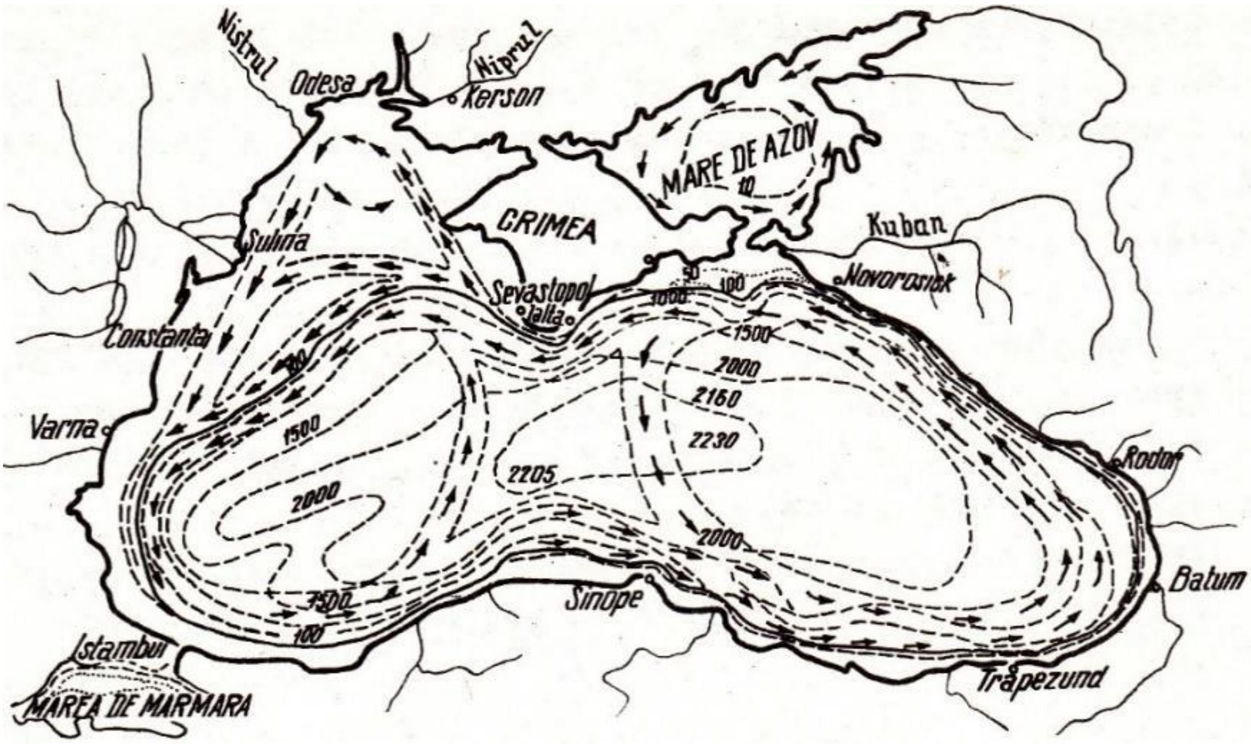


Fig. 1. 1 – Map of currents in the Black Sea, created by Professor Knipovici [1]

The Black Sea is a semi-enclosed basin, of relatively small size, with an area of 466,000 km^2. It is located in the eastern part of Europe, between 40° 55' and 46° 32' north latitude, respectively 27° 27' and 41° 42' east longitude.

The hydrographic basin of the Black Sea can be divided into two approximately equal parts (Fig. 1.2), having different morpho dynamic and hydrological characteristics. In the eastern area, the continental shelf is very narrow, while in the western and north-western basin, the plateau occupies one third of the region, where the main tributaries of the Black Sea flow (the Danube, the Dniester, the Dnieper and the Bug). The northwestern region is considered an estuary, due to the hydrological processes related to the freshwater inflow, but the main characteristic defining the Black Sea is the stable hydrodynamic structure of the water stratification.

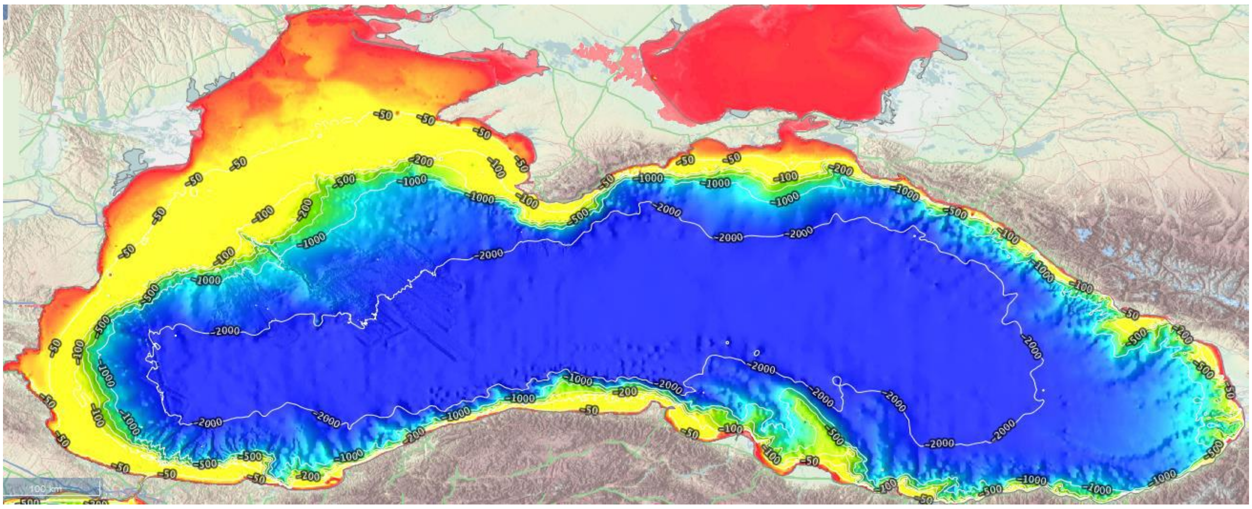


Fig. 1. 2 – Black Sea, topography [35]

The Black Sea is permanently anoxic below about 100 m depth. Driven by the intensive agricultural production of centralized economies and receiving 70% of its nutrient load from the River Danube, the north-western shelf of the Black Sea was experiencing primary symptoms of eutrophication by the 1970s. By the 1980s, secondary symptoms including hypoxia and mass mortality of benthic flora and fauna were occurring. The collapse of the centralized governments and the resulting deintensification of agriculture, the main driver of eutrophication, were followed by signs of recovery [40]. Nowadays, the Black Sea Basin is a region under growing population and continuous economic developments, and various coastal and marine uses, such as tourism industry, shipping and maritime transport, oil and gas exploitation, fishery and aquaculture, dredging. On the other hand, due to its geographical, political and economic location, the Black Sea is listed as one of those regions that will be heavily affected by the global climate change and related sea level rise. At the same time, the Black Sea, one of the most vulnerable inland seas in the world, is strategic for increased coordination and targeted synergies between the different sectors reliant on the sea (i.e. 'blue economy') as stressed also by the EC Black Sea Synergy (Joint Staff Working Document Black Sea Synergy: review of a regional cooperation initiative economy', Brussels, 20.1.2015, SWD, 2015).

It is considered an internal brackish sea with 17‰ salinity under the main rivers impact, mainly Danube, sedimentary and anthropogenic influence.

1.2. Theoretical elements regarding the numerical models

1.2.1. Description of MOHID model "MOdelo HIDrodinamico"

Currently, in the NIMRD, the MOHID model is being studied in order to implement it at the Black Sea level and locally at a higher resolution, along the coast.

The model is realized on the complex modular principle, respectively each module can request or receive information / results from other modules, thus ensuring a continuous correlation in successive calculation steps.

The hydrodynamic module is based on hydrostatic flow, in the context of the Boussinesq approximation. The spatial discretization is done at finite volumes, and the network is octagonal, respectively in generic coordinates in the horizontal plane, respectively vertical. Network computing points are defined by the Arakawa C method, with modules for Euler or Lagrange transport.

The MOHID model running in the NIMRD "Grigore Antipa" uses CMEMS products, which contain global daily scaterometric observations (L3 package), based on L2 scaterometric products, which belong to the EUMETSAT (OSISAF) Aeolian Center of KNMI (Koninklijk Nitulands Meteor). The different datasets within the product can have different resolutions, ranging from 12.5 km and 25 km (Metop-A and B), to 25 km and 50 km (QuikSCAT, ScatSat-1 and Oceansat-2), depending on scatterometer and processing. The data from the ascending and descending crossings are stored and processed in separate files. Only OSISAF L2 observations that have passed KNMI quality control are used for CMEMS L3.

The network used is a common broadband network that covers the entire Earth. Network spacing is as follows:

- 0.125 degrees for scaterometric products with a width of 12.5 km L3,
- 0.25 degrees for skatermeters with a network resolution of 25 km L3,
- 0.5 degrees for scaterometric products with a network of 50 km L3.

The coverage domain of the L3 product is composed of the surface wind based on the scaterometers, which is interpolated on the basis of a common latitude-longitude network. Consequently, the L3 wind covers the planetary ocean using a common projection with a constant latitude and latitude step of 0.25° or 0.125° or 0.5° respectively [38].

1.2.2. Description of the POM model "Princeton Ocean Model"

The POM model has been implemented in the NIMRD Grigore Antipa in collaboration with MHI (Marine Institute of Hydrophysics in Sevastopol) and runs from 28.01.2009, presenting almost daily, on the website www.rmri.ro, forecasts (3-5 days), at three hours) regarding the water level, temperature and salinity of the sea, as well as the field of sea currents for the Romanian coastal area up to 30º5 'E longitude. The results are presented in form of animations (gif's) as forecasts for three consecutive hours.

The POM (Princeton Ocean Model) numerical model consists of a main program and a set of modules, totaling approximately 15,000 lines of code. The main program is under different variants (POM98, POM2K, OZPOM, etc.) and contains the operations of initialization and separation of the iterative calculation for the three-dimensional internal mode. These operations are performed using the subroutines: advq, profq, advu, profu, advv, profv, advt (for temperature or salinity), proft (temperature or salinity), advare. The model belongs to a class of models that addresses the phenomena of mesoscale circulation, this being used in different areas as part of the forecasting programs.

The POM model is a three-dimensional circulation program that uses the primitive equations of the movement of free-floating water bodies in a sigma vertical coordinate system. A feature of the model is the inclusion in it of a module for closing the turbulence, a factor that allows the faithful determination of the Eckman surface and the dynamics of the bottom layers. The POM model is designed to represent marine physical processes on a scale of 1-100km, for 1-30 days. The variables determined are the three components of the velocity field (u, v, w), as well as temperature, salinity, turbulent kinetic energy and macroscale turbulence. The momentum equations are nonlinear and incorporate a variable parameter of Coriolis force. The control equations of the thermodynamic processes and of the temperature and salinity distributions take into account the variations of the water masses brought by coastal upwelling processes and by the horizontal advection processes. The free surface elevation is calculated prognostically, which reduces the computation time and can numerically simulate sea level rise in the event of storms. Other calculation variables are density, vertical turbulent viscosity, vertical turbulent diffusion. The model really includes the geometry of the coastline and the topography of the seabed. In the POM model, two simplifying assumptions are used:

- It is assumed that the weight of the fluid is equally balanced by the pressure (hydrostatic hypothesis).
- Differences in density are neglected only if they are not multiplied by gravity. [57]

1.3. Physical and hydrological features

In the Black Sea, depending on the baric field, the following types of circulation are known: south-west (Fig. 1.3), west (Fig. 1.4), north-west (Fig. 1.5), north (Fig. 1.6), south-east (Fig. 1.7, Fig. 1.8), north-east (Fig. 1.9), east (Fig. 1.10).

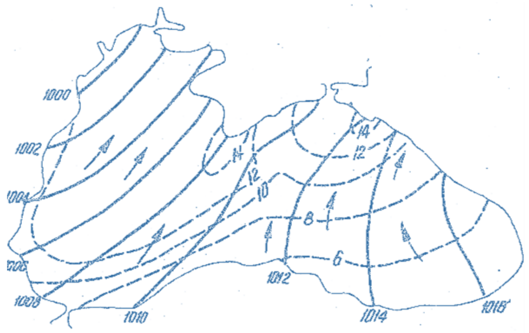


Fig. 1. 3 – South-west atmospheric circulation [1]

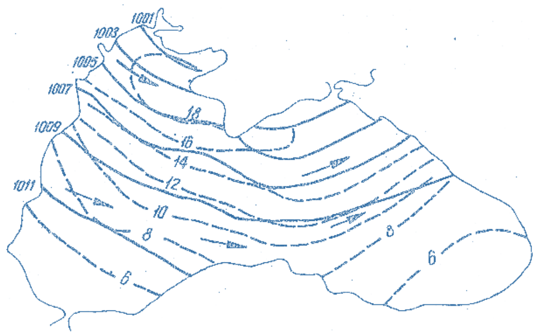


Fig. 1. 4 – West atmospheric circulation [1]

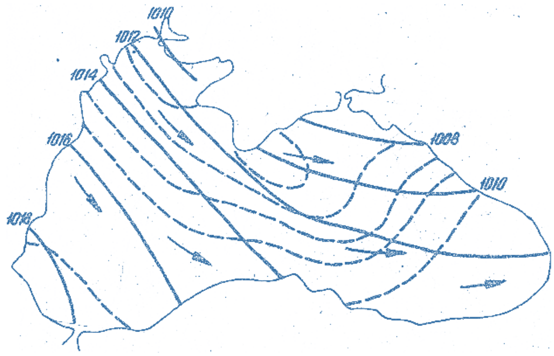


Fig. 1. 5 – North-west atmospheric circulation [1]

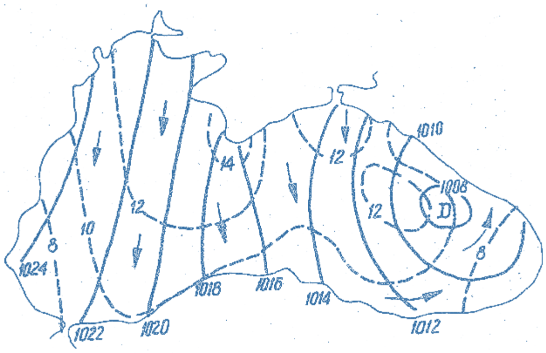


Fig. 1. 6 – North atmospheric circulation [1]

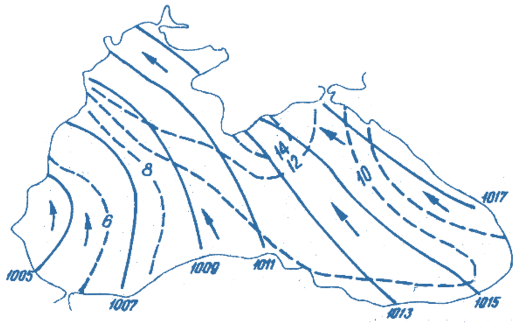


Fig. 1. 7 – South-east atmospheric circulation [1]

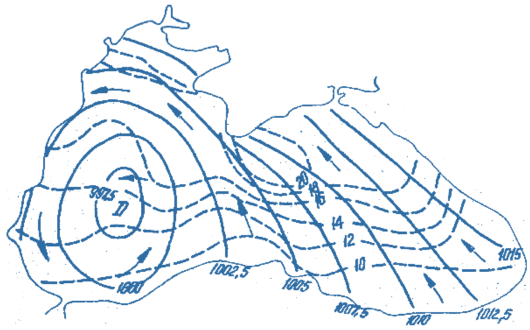


Fig. 1. 8 – South-east atmospheric circulation [1]

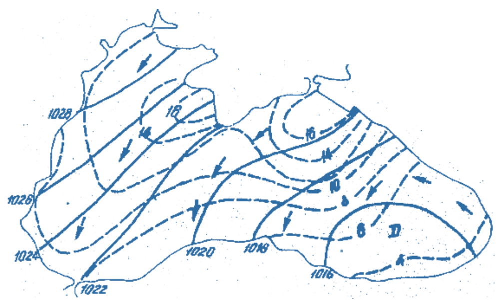


Fig. 1. 9 – North-east atmospheric circulation [1]

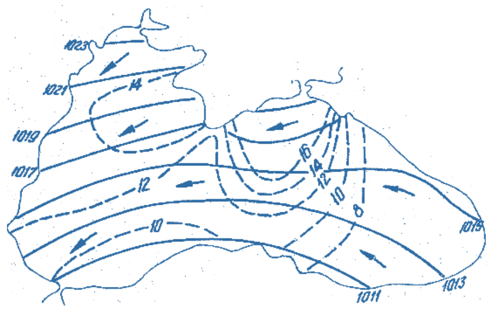


Fig. 1. 10 – East atmospheric circulation [1]

According to Cerneakova, 48% of the year, the Black Sea is subjected to a baric field that causes a uniform circulation, and 52% of the time the baric field has a weak gradient. From an occurrence point of view, the most stable circulation is from north and north-east, the cyclonic circulation being the most unstable. The western circulation appears when in the north part of the Black Sea depression takes place. Depressions that pass over the Black Sea move north-east, the cases in which the movement is from north to west are very rare.

The study area starts in front of Danube Delta Biosphere Reserve and continues with the southern part of Romania and whole Bulgarian coast, which is under human pressures and demography development, having all activities effects on the sea waters.

Romanian coast is divided into two geographical units: the northern unit and the southern unit, with Cape Midia as an inflection point. The northern sector is about 170 km long and includes the Danube Delta, which is an important part of it. This sector extends from the border with Ukraine to Midia port. Since the Danube Delta forms a large part of this Nordic sector, a representative feature is the presence of lagoons and low-altitude sand dunes (belts) which generally do not exceed a height of 2 m.

The southern sector is about 74 km long and stretches from Midia Port to the border with Bulgaria. This sector is characterized by high cliffs, which have a maximum height of 80 m in the Constanta port region. Compared to the northern sector, the southern sector has small beaches with a multitude of coastal protections, and in some sub-sectors the beach eroded completely, allowing the waves to break directly into the base of the cliffs. [2][3]

1.3.1. Wind regime

The hydrodynamic processes that take place in the marine environment are generated by the complex phenomena of the interactions between sea and atmosphere. The kinetic energy exchanges between the two environments determine the formation of sea currents and waves. In both cases, the movement is provided by the tangential tension of the wind on the sea surface, which transforms into quasi-uniform circulation in the active layers and in undulating motion on the surface of the water.

The wind regime is characterized by the local physio-geographical conditions, the topography having the most important role. The dynamics of the air masses in the coastal area of Romania is characterized by seasons.

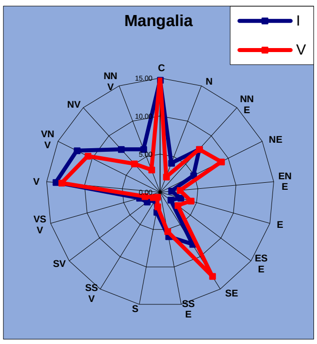
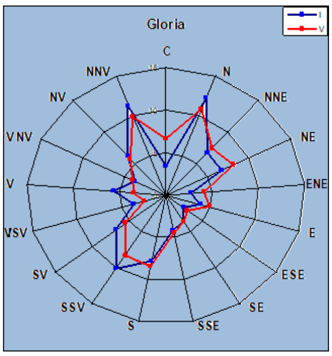
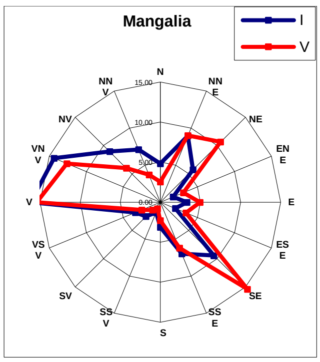
Complete or partial analyzes were performed on several data rows:

- sets from the stations Mangalia, Constanța, Sulina and Gloria [8] [9] [10], according to the standard international weather reports of the weather stations.

The periods of the data sets are, in order:1975-2013,1964-2002, 1952-2016, 1952-2016, 1953-2016, 1983-2002, the sets having respectively, 62291, 138946, 286056, 256792, 535137, 62283, 627594 values. The analysis was performed for the distribution according to the wind direction (winter and summer) (Fig. 1.11).

In the first column, the wind roses taken into account, the periods or days of calm in which the wind speed was 0. In the second column, the roses of the Gloria Platform station are presented with and without the calm period. In the third column are presented the roses without the period of calm for the three stations.

The roses were made based on all the values of the data sets, in the form of percentages. Thus, in the case of Mangalia station, when the rose includes the periods of calm, it can be observed that this period coincides with about 15% of the distribution, and when it does not include, the distribution in the west and west-northwest direction increases percentage exceeding the limit of 15 % of the rose. Blue colored roses are those that include the calm period in the distribution.

Wind rose (%) (including v=0)	Wind rose (%) Gloria (including v=0) Gloria (without calm)	Wind rose (%) (without calm)
		

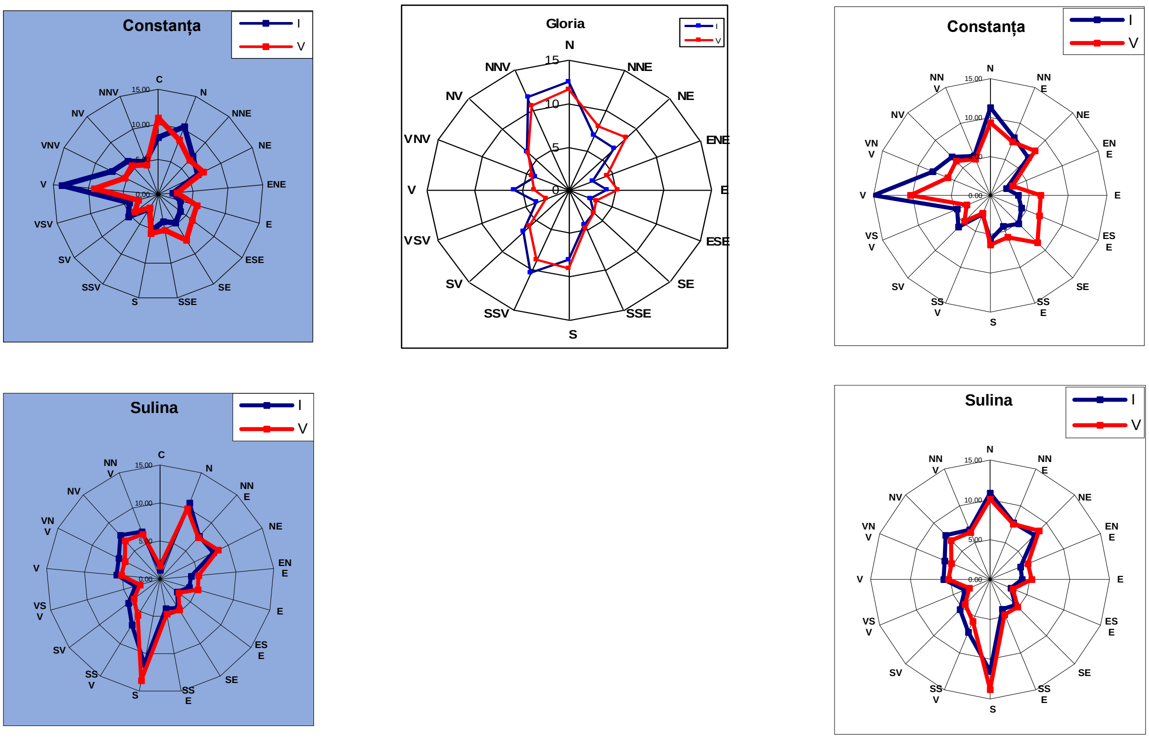


Fig. 1. 11 – Wind direction distribution (winter - I and summer - V) with calm period and no calm period from total records [7]

The unusual appearance of the roses for Mangalia and Constanta, in relation to the stations Sulina and Gloria Platform, suggest particular local conditions.

The study brings together four sets of data, three along the shore, giving a spatial image of how wind values can vary from north to south, not only offshore.

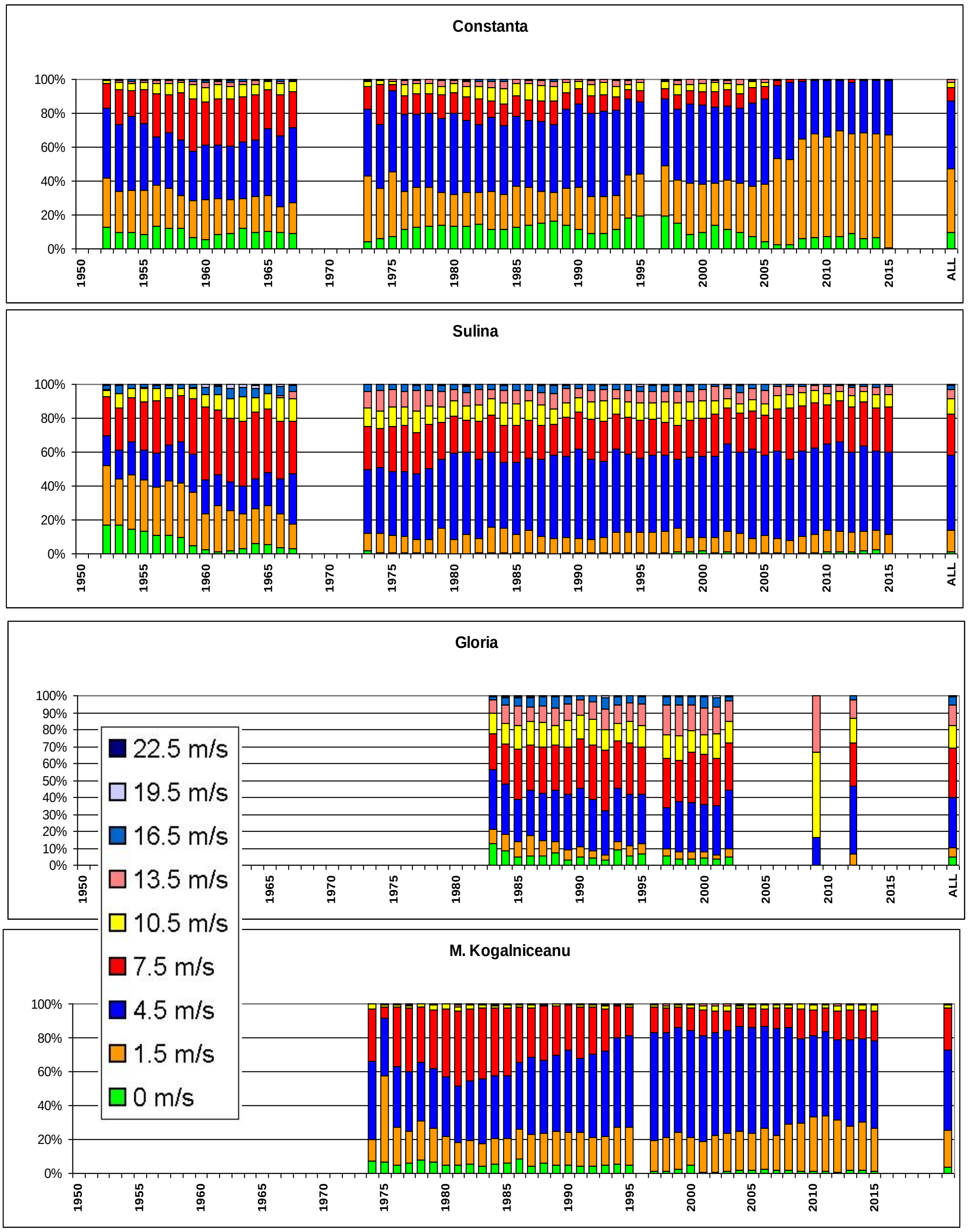


Fig. 1.12 – Multi-annual wind speed distribution (average values) for each set of data (1950 - 2015) [7]

Wind velocity results were analyzed as a percentage of the entire distribution (in classes from 0 m/s to 22.5 m/s) for each year (Fig. 1.3). In the last decade, wind speeds in Constanta have begun to decrease, as nearly 95% of wind speed is in the range 0-6 m/s. This result may be related to the fact that the meteorological station is surrounded by

new buildings (which have been developed since 2005), which have affected the flow of air (and, of course, the wind speed, as it is recorded).
For the Sulina station, the wind speed classes are almost stable, but the higher speed class (10.5 - 16.5 m/s) are getting smaller. Even so, in this dataset the wind speed values reach 19.5 m/s, and the global wind speed percentage that exceeds 10.5 m/s is almost 20% per year, but for the Constanta and Mangalia stations this percentage is less than 5%. At the beginning of the data set there is a notable period when the wind speed distribution from 0 to 3 m/s was about 40%, probably corresponding to a warmer period. For the Gloria Platform station, the wind speed of 9 m/s and above, occupies 30% of the range; calm and breeze are less than 10%, and the remaining 60% is divided between the 4.5 and 7.5 m/s classes. The speed classes of M. Kogalniceanu do not vary as much, their distribution shows that 75% of them are in the value range 0 - 6 m/s. It was intended to present the general wind conditions in offshore areas along the coast and in land. Based on the analysis and the results obtained, there is a change in the distribution of small values.[7]

1.3.2. Wave regime

The kinetic energy exchange between the marine environment and the atmosphere determines the formation of waves. The movement provided by the tangential tension of the wind at the sea surface becomes a ripple motion at the surface of the water.

The meridional orientation in quasi-totality of the Romanian coast and the bathymetric characteristics, make it possible to amplify the degree of marine agitation, through the waves produced by the wind, acting from a sector of 180° between N and S on the right side of the meridian, depending on their duration and intensity.

The results of the measurements from 01.01.2017-31.12.2017 were analyzed (N = 1105 observations). The measurement was performed three times per day and compared to the reference period (1971-2016). The observations were made in the area of the Lighthouse of Genovese (44° 10'19" N and 28° 39'52" E), located near the Port of Constanța. The maximum depth of the seawater is 8m.

In 2017, the marine agitation can be characterized as weak in December (the calm period had a maximum of 41.94% / 31 days). The wind waves presented a minimum of 11.83% in winter (December) and the maximum in the summer season - in August of 48.39% (Table 1.1). The appreciation also takes into account the height of the observed waves that exceeded 1.25 m.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Hmax (m)	4.00	1.8	1.2	2	1	0.8	1.8	1.5	3.2	3.3	1.8	1.5
Hmin (m)	0.20	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Havg. (m)	1.02	0.74	0.60	0.70	0.49	0.45	0.57	0.64	1.30	0.75	0.66	0.51
Tmax (s)	7.70	7.00	7.10	7.70	4.00	7.00	6.50	5.10	6.90	6.90	7.50	5.70
Tmin (s)	2.30	2.40	2.40	2.40	2.30	2.50	2.20	2.40	2.50	2.70	3.00	2.70
Tavg (s)	4.36	3.38	3.89	4.23	3.48	4.01	3.85	3.68	4.62	4.39	4.13	3.64
0-0.1 m (%)	25.81	11.90	29.03	16.13	33.33	22.22	17.20	15.05	10.75	31.18	22.58	43.01
Wind wave (%)	26.88	39.29	36.56	29.03	36.56	24.44	37.63	48.39	39.78	19.35	34.41	11.83
Swell (%)	9.68	20.24	8.60	17.20	2.15	16.67	9.68	5.38	17.20	20.43	10.75	4.30
No data (%)	37.63	28.57	25.81	37.63	27.96	36.67	35.48	31.18	32.26	29.03	32.26	40.86

Table 1. 1 – Wave characteristics in Constanța, between January and December 2017 [22]

The maximum degree of sea agitation, on the Beaufort scale, was of grade 5-7 (maximum wave height of 4.0 m) registering in January (Fig. 1.13, Table 1.1). the maximum value was determined on 05.01.2017, when the maximum wind speed was 6.8 m/s from the NNV direction. Compared to the reference period, a maximum of ~ 6m of wave height was recorded in January 1981 and 6.5 m in February 2012.

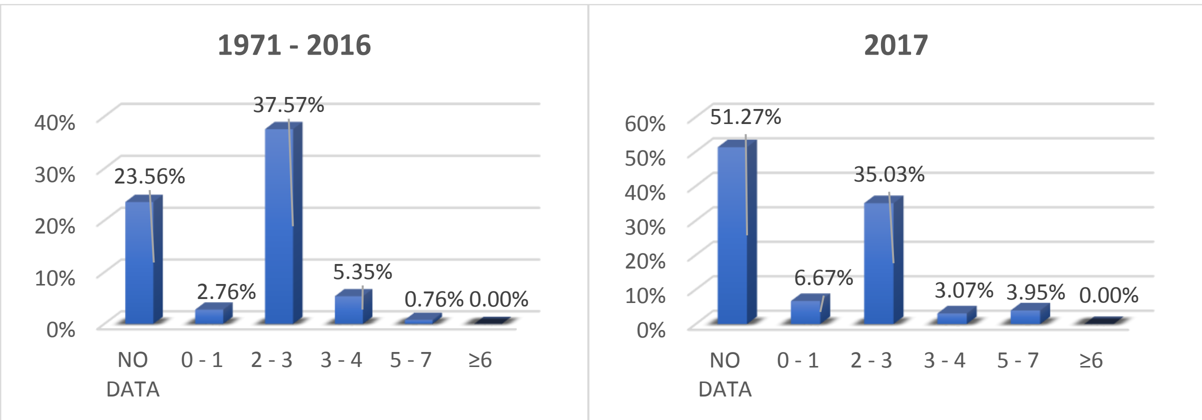


Fig. 1. 13 – Sea state of agitation a) the reference period (1971-2016) and b) 2017 (Beaufort scale) [22]

Their distribution along the propagation directions is determined by the distribution of the prevailing winds and, respectively, the general orientation of the shore. Thus, 53.8% of the wind waves propagate from N, NNE and NE, while, due to the higher refraction at large wavelengths, 38% of the wave propagates predominantly from E and 32% from SE (Fig. 1.14).

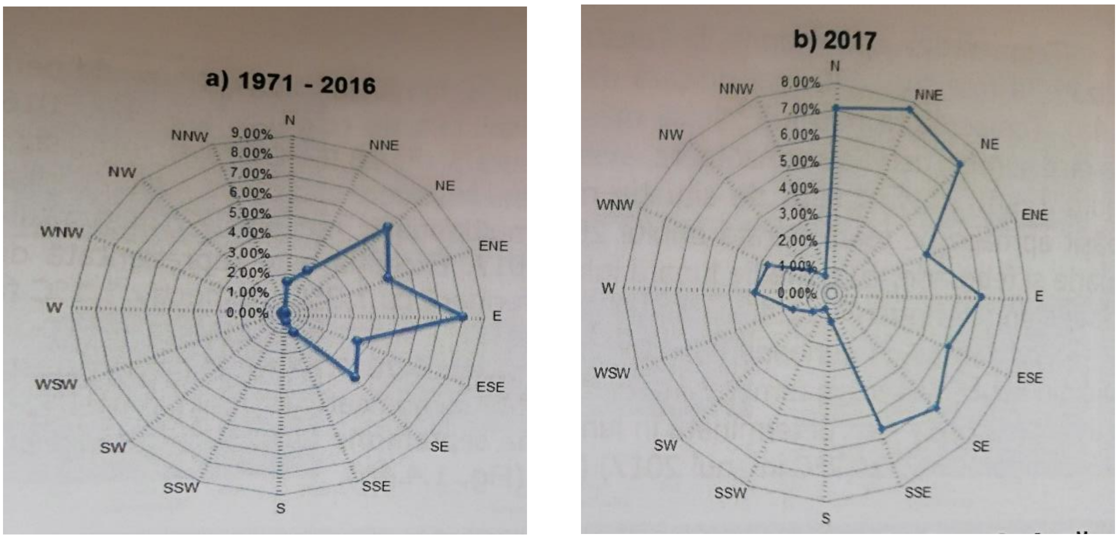


Fig. 1. 14 – The wave rose ate Constanța in a) the reference period (1971-2016) and b) 2017 [22]

1.3.3. Marine current regime

The sea currents circulation in the Black Sea is influenced, on one hand, by the cyclonic structure of the wind, on the other hand by the contrast between the ascent force of the fluvial freshwater flows and the intake of salt water from the Bosporus Strait. All these combined with Coriolis force induce the cyclonic circulation in the west basin.

The marine current circuit has a peculiarity that makes it unique. In the upper layer there is a permanent, peripheral, current (RIM current) that forms, on a large scale, a cyclonic swirl. This current encompasses two secondary circuits in the east and west of the basin.

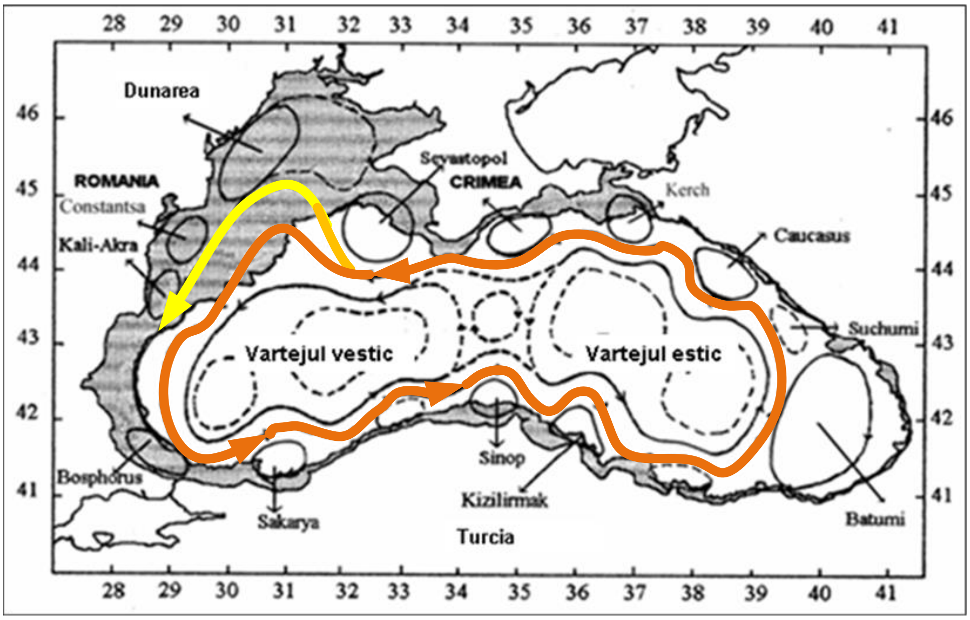


Fig. 1.15 – Currents circulation in the Black Sea Basin [4]

The average RIM / CPMN current is 0,3-0,5 m/s, and at the center of the jet it reaches 0,4-0,6 m/s, under favorable conditions it can exceed 1,5 m/s. Cyclonic circuits have speeds of 0,2-0,4 m/s at the periphery and 0,1-0,2 m/s at the center. Between them, there is an unstable area with currents that have low speeds, and the RIM / CPMN ramifications extend to the western continental shelf (Fig. 1.15).

Since the dynamic method cannot be applied to the continental shelf, the spatial expansion of these phenomena can only be determined by direct measurements. Due the transiting phenomena it's difficult and random to obtain the necessary data.

For direct high spatial resolution measurements (both horizontally and in depth), data from an Acoustic Doppler Current Profilers (ADCP) was used.

In the image below the current velocity (intensity) can be observed, using an artifact of exaggerating the values to be observed three-dimensionally. The current speed is between 0.01m/s and 0.5 m/s. [7]

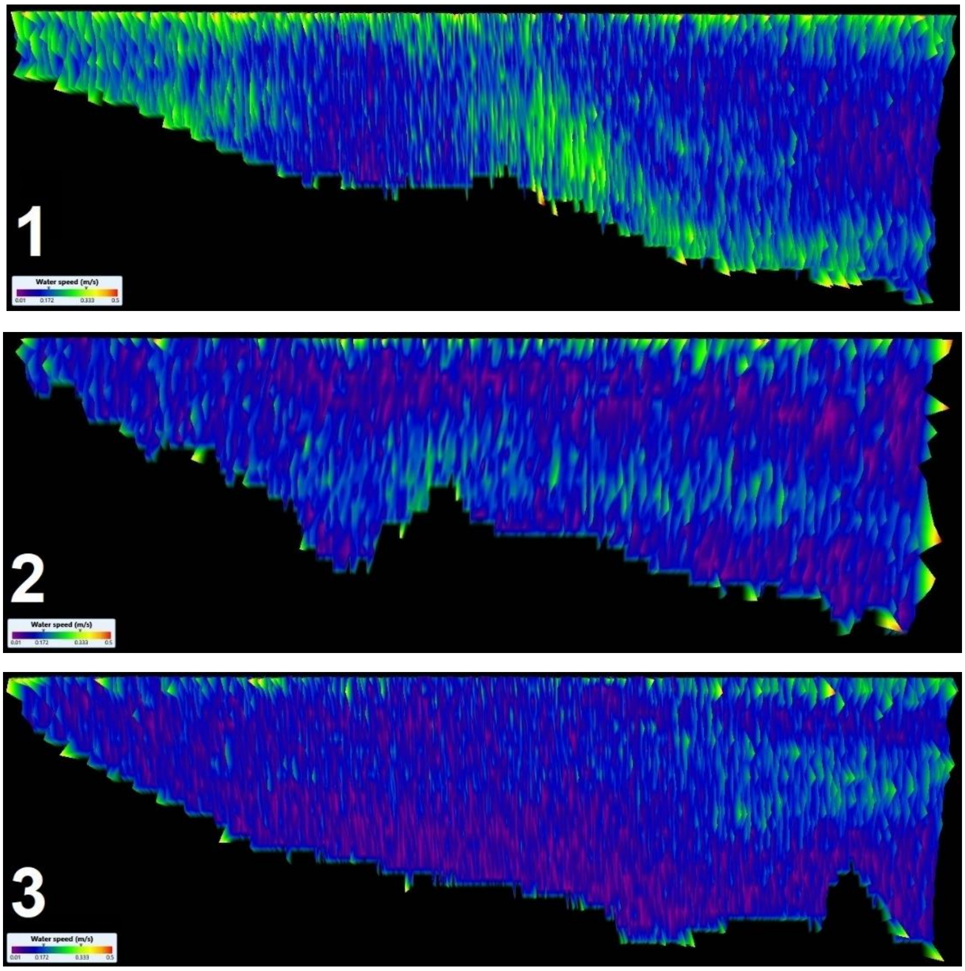


Fig. 1. 16 – Water current profile

Since the measurement frequency is high, the amount of data collected is very high and it has been necessary to mediate it at a 5-second interval. The images above are the result of mediation (Fig. 1.16). The average water flow speed was calculated for the three current profiles. Due to the fact that the sea state was good with no waves, the current speed was small, in consequence so was the current flow through the section (First section - 0.15 m^3/s, second one – 0.11 m^3/s and the third one – 0.09 m^3/s). This is mainly linked to the change in bathymetry.

Surface current values were extracted and inserted in ArcMap, where the data could be vectorized in the form of arrows (Fig 1.17). The values interpolation was only possible after they were mediated over long time intervals so that the distance between the profiles and the distance between the values would no longer be a problem for the interpolation method.

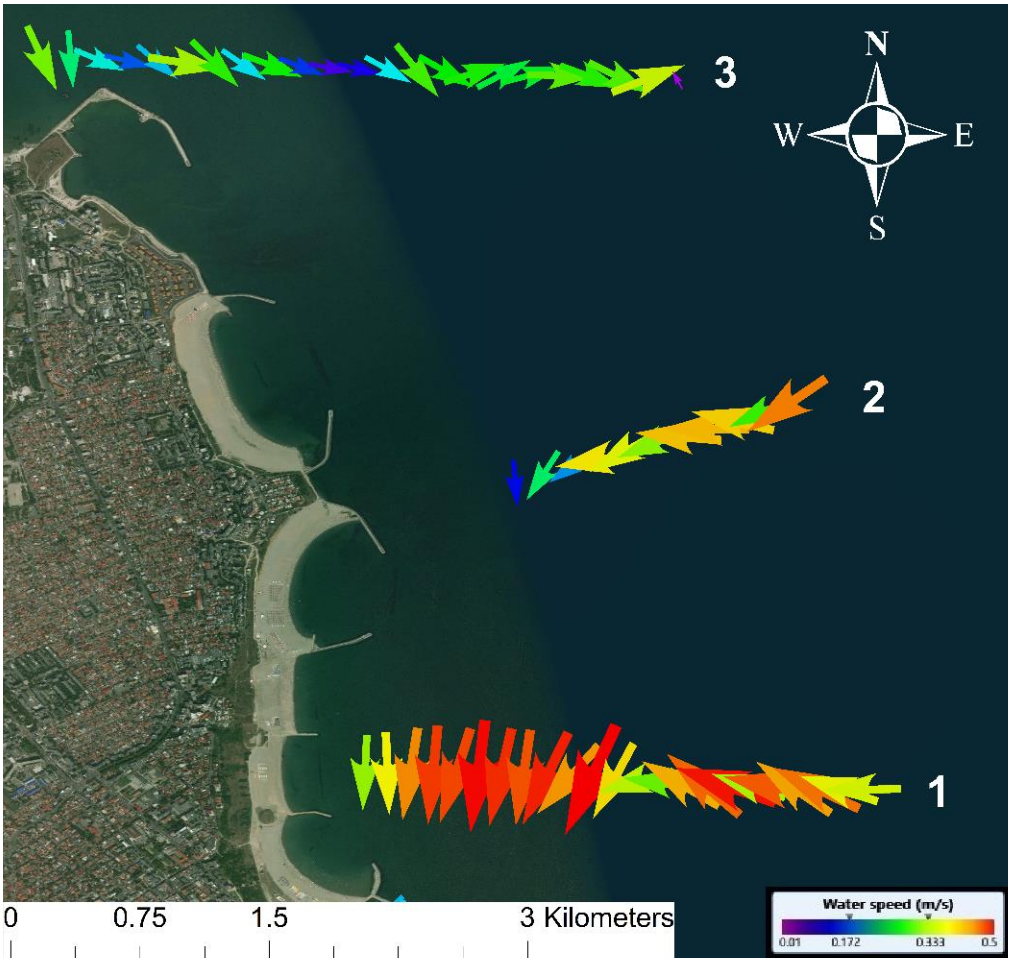


Fig. 1. 17 – Current speed and direction

Based on the map made, the general direction of the current is from north to south, with the exception of the first profile from the south, which shows that the direction of the marine current from the end to the middle of the profile is heading to WNW and from the middle to the start of the profile it changes its direction to the south. One possible explanation is be that in that area a swirl was caught, but without other thickening profiles, it is impossible to make an appreciation.

From a physical perspective, the sector between the two shore units, having as the northern boundary Mamaia Bay and the southern border a commercial port, thus representing an enclosed shore unit and an isolated sedimentary cell by marine obstacles. The regional climate is a temperate continental moderate, due to the Black Sea that has a strong influence, as it induces a strong thermal inertia. [7]

1.3.4. Water temperature

The temperature of the sea water, in Constanța, for an analyzed period of 12 months, was 2.2 °C higher than the reference one (1959-2016, Fig. 1.18a). The maximum daily temperature measured at 28.03 °C was recorded on August 6, not at all surprising, given the evolution of air temperature compared to the multiannual situation, the averages in Constanta exceeded them almost throughout the year. The exception is represented by January and February, with a monthly average below 1.3 °C, respectively 1.1°C compared to the period of reference (Fig. 1.18b).

Compared to the reference period, the year 2017 can be characterized as an atypical year from the thermal point of view with significant positive differences. Thus, the maximum difference of 2.5° C was determined in September (19.2° C in the period 1971-2016 compared to 21.7° C in 2017).

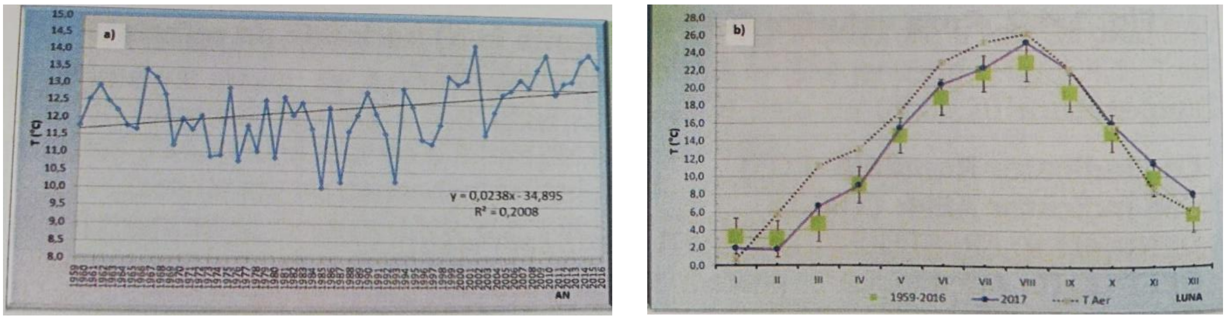


Fig. 1. 18 – The comparative situation of the multiannual (a) and monthly (b) averages of seawater temperature in Constanța, between 1959-2016 and 2017. [22]

The water temperature in the surface layer for the period 1959-2016 has an increasing trendline, with approximately 0.02 °C / year (Fig. 1.18a). Throughout the western continental shelf of the Black Sea, and the water column, the water temperature recorded values are between 4.4 °C and 24.0 °C. The minimum values belong to the Cold Intermediate Layer (SIR ≤ 8 ° C) corresponding to the East-Constanta 3 station (March) at a depth of about 30 m. In the spring period the temperature distribution is homogeneous from the surface to the bottom layer with values ranging from 4.4 to 9.2 °C. The maximum values were recorded at the station Constanța 20 m and Constanța 30 m in the surface layer. In the central part of the Romanian continental shelf, the surface temperature distribution follows the direction of the anticyclonic currents that arise due to strong seasonal winds. In the hot season, the temperature is homogeneous from the surface to the bottom, with temperatures between 16.6 °C and 24.0 °C. Due to the strong land-sea interaction, the minimum temperature of 16.6 °C was recorded at the station Constanta 5 m. The strong stratification is observed from the depth of 30 m depth towards the bottom. During the autumn period, the temperature distribution is homogeneous on the surface with values between 10.4 - 13.2 °C. The maximum values were recorded at Portița 6 station, in the surface layer (Fig. 1.19).

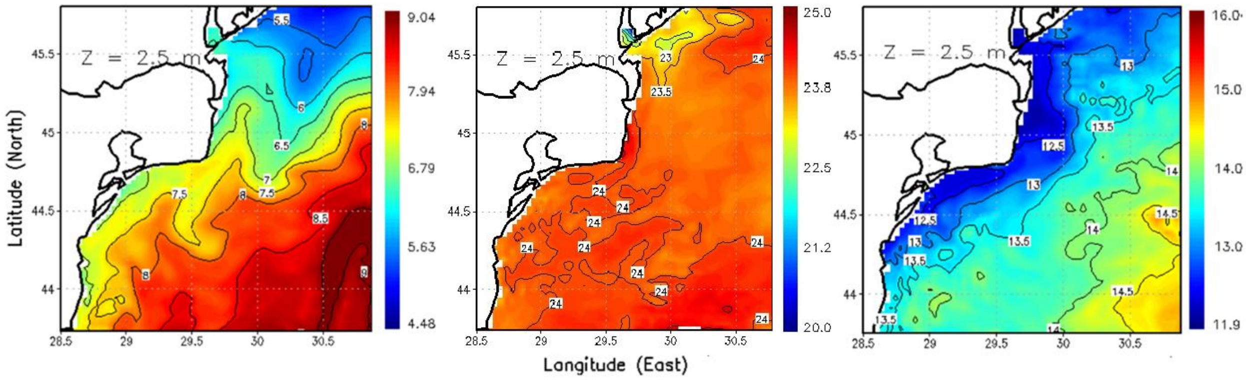


Fig. 1. 19 – Horizontal temperature(°C) distribution - POM numerical model results 23.03.2017 (a), 27.06.2017 (b), 15.11.2017 (c) [36]

The vertical distribution of the water temperature depends on the thermal regime of the atmosphere and the dynamic factors of the sea (currents and waves), which produce the mixture of the water bodies. Intense mixing of water generally reaches depths of 100 - 150 m and, very rarely, 200 m. The water column has three obvious layers in the western corner of the Black Sea. During the hot season, the upper layer waters are separated from the cold water (SIR) by a layer with a higher density gradient (seasonal thermocline) that prevents the mixing and thermally isolates the bottom waters, which remain at low temperatures.

The water bodies, in July 2017 (the period during which the NIMRD expedition took place), present a strong stratification characteristic of the warm season. The maximum water temperature is in the surface layer. A feature of the water bodies in the western part of the Black Sea is represented by the minimum salinity, located in the surface layer (SSQ) due to the contribution of freshwater and weather conditions. The minimum temperature was located in the depth layers - in the Cold Intermediate Layer (SIR) - waters characterized by the maximum salinity value.[22]

1.3.5. Sea level

The level of the Black Sea is always changing undergoing periodic and non-periodic vertical oscillations. These variations may be due to increased volume or local deformation due to wind, atmospheric pressure and tides. The oscillations of the sea basin are largely influenced by the contribution of the rivers that flow into it. Given the periodicity, the sea level is minimum in winter and maximum in summer, due to the high flow of water resulting from the snow melting.

The first sea level measurements of the Black Sea at the Romanian coast have been performed in Sulina since 1856. These measurements were performed using a graded mirror but the exact place where it was mounted is not known. Following these sea level observations, the European Commission of the Danube publishes the results in 1857. The reference level of the Black Sea is established after the mediation of all the data collected until 1858. In this period the zero level of the sea is fixed with the help of a tide gauge at the base of the Sulina lighthouse, and from 1869 the reading of the tide gauge is established at three intervals per day. These intervals are changed three times, until they reach the interval 7^{00},13^{00} and 19^{00}.

In the case of the sea level variations at the Romanian coast, the predominant factors are the meteorological and hydrological ones, since the tide governed by the astronomical factors is too small to be taken into account.

The sea level, is a status indicator of the coastal zone, and in 2017 it had three distinct oscillation stages. Compared to the reference period (multiannual monthly averages in the period 1933-2016) it surpassed the monthly average values since the late spring.

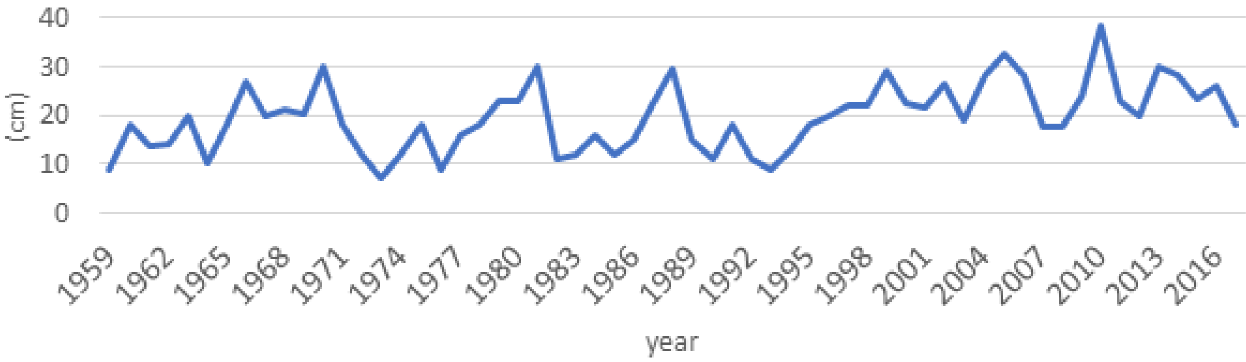


Fig. 1. 20 – Sea level oscillations at the Romanian coast - annual averages [22]

A maximum of 25.81 cm (2.3 cm above the multi-monthly value of the reference period) was registered in June 2017, and the minimum of 11.28 cm in October (1 cm above the muti-monthly value of the reference period) (Fig. 1.20).

Regarding the evolution of sea level at the Romanian coast, in the long term, the tendency is increasing, with a rate of approx. 0.19 cm / year. [22]

1.3.6. Water salinity

The sea salinity at the Romanian coast in 2017 ranged from 13.03 to 20.98 PSU (average 18.50 PSU). The minimum was measured in surface waters, at Portița 5, in March as a result of the freshwater fluvial contribution, and the maximum at the bottom of the sea (East Constanta 7 station, depth 90 m) in November. The spatial distribution of the salinity along the Romanian coastline shows how the Danube fresh water travels with the currents along the coastline (Fig. 1.21).

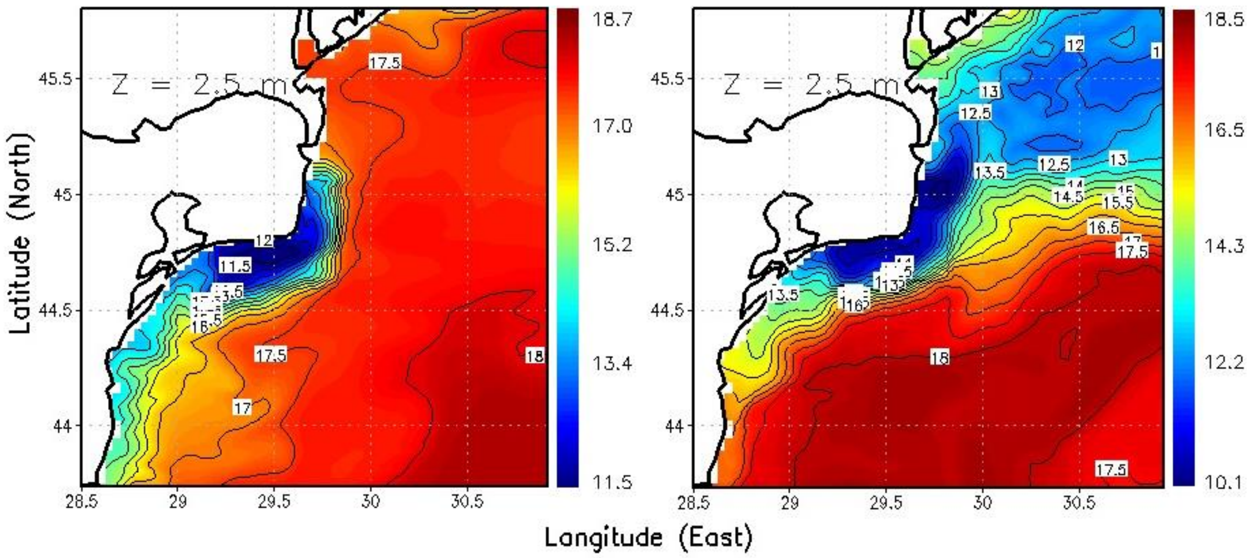


Fig. 1. 21 – Horizontal distribution of surface water salinity along the Romanian coast, 19.03.2017 (a) – 22.06.2017(b) [36]

In the long term, the monthly averages for 2017 are higher than those for the period 1959-2016. In 2017, the absolute minimum salinity in Constanța (Mamaia resort area) was 10.71 PSU (May 8) and the absolute maximum 20.85 PSU (September 26). The annual average of 2017 represents the historical maximum previously held since 1990 (16.45 PSU) [22]

1.3.7. Air temperature

Solar radiation balance has a value of 45-50 kcal/cm^2 on the areas of Romanian littoral, where the clear sky is predominant, during summer (within June and July) this balance is 8-9 kcal/cm^2, in contrast with the cold season (December and January), it has a negative value, under -1 kcal/cm^2.

In the coastal zone of the Black Sea, the presence of large lacustrine surfaces together with the hydrographic basins and specific semiarid climate vegetation induce in this region a mild continental climate, with a specific element of breeze (due to the sea – during day and of land - during night).

The average annual temperature is 11,2°C (Table1 1.2). Winter is mild too, with average temperatures of 1.3 °C, while spring is cooler compared with the inland regions. Due to the eastward coastline orientation, daily course of breeze circulation, the summer is longer and cooler compared with the inland, with average temperatures between 21.2 °C. Autumn is long and warm (average temperature of 13 °C) because of the warming influence of the Black Sea (Table 1.3).

Monthly and annual averaged air temperature is an important climatic parameter, which was analyzed based on registered data from meteorological stations (Constanta and Mangalia), on a period of 100 years, emphasizing that all monthly temperature averages had a positive value. [22]

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual	Amplitude
Constanţa 1901-2000	0	1.1	4.4	9.5	15.1	19.6	22.1	21.9	18.2	13.2	7.6	2.8	11.3	22.1
Mangalia 1961-2000	1	2.0	4.6	9.6	15.0	19.6	21.8	21.6	18.0	13.1	8.1	3.4	11.5	20.8

Table 1. 2 – Annual monthly temperature (°C) in Constanta and Mangalia, (NIMRD internal studies - 2007) [22]

Season	**Winter**	**Spring**	**Summer**	**Autumn**
Constanta	1.3	9.7	21.2	13.0
Mangalia	1.5	9.6	21.3	13.1

Table 1. 3 – Seasonal temperature (°C) in Constanta and Mangalia, (NIMRD internal studies - 2007) [22]

1.3.8. Annual precipitation

The average annual precipitation along the coastal zone of the Romanian shore is below 398 l/m2. The highest rate of precipitation in the area of Constanta is in June (41.7 mm/month), and the minimum is in March (23.5 mm). In the drought period the annual averaged rate of precipitation is less than 25 mm. Also, in the case of Dobrogea region the studies show that if the precipitations quantity exceeding 50 l/24 h it will induce a flood where the soil is dry. [22]

1.4. The Danube River

The Danube River is the second largest river in Europe after the Volga covering 801,463 km^2. It lies to the west of the Black Sea in Central and South-eastern Europe. To the west and north-west the Danube River borders on the Rhine River, in the north on the Weser, Elbe, Odra and Vistula River Basins, in the north-east on the Dniester, and in the south on the catchments of the rivers flowing into the Adriatic Sea and the Aegean Sea. [13]

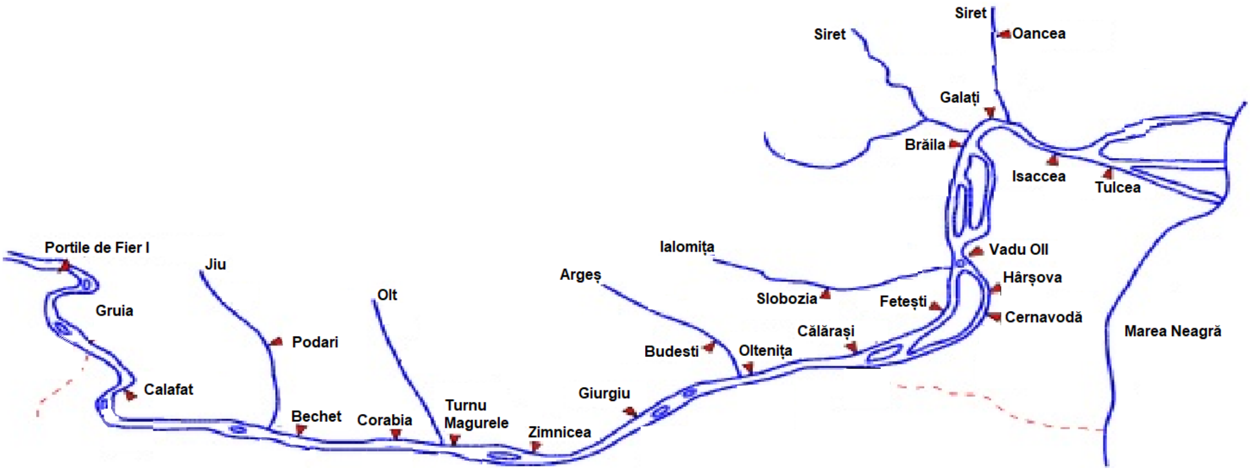


Fig. 1. 22 –The Danube River - Romanian part [14]

The hydrologic regime of the Danube River, in particular the discharge regime, is distinctly influenced by the regional precipitation patterns. This is well illustrated in the figure bellow (Fig. 1.23), which shows the surface water contribution from each country to the cumulative discharge of the Danube. Austria shows by far the largest contribution (22.1 %) followed by Romania (17.6 %). This reflects the high precipitation in the Alps and in the Carpathian Mountains. In the upper part of the Danube the Inn contributes the main water volume adding more water to the Danube than it has itself at the point of confluence of the two. In the middle reach it is the Drava, Tisza and Sava, which together contribute almost half of the total discharge that finally reaches the Black Sea. [13]

Based on the medium and long-term statistical elements, the forecast of the monthly average and extreme monthly flows values of the Danube (Fig. 1.22) at the entry into the country (Baziaş section) for the period January - December 2019, are presented below (table 1.4): [14]

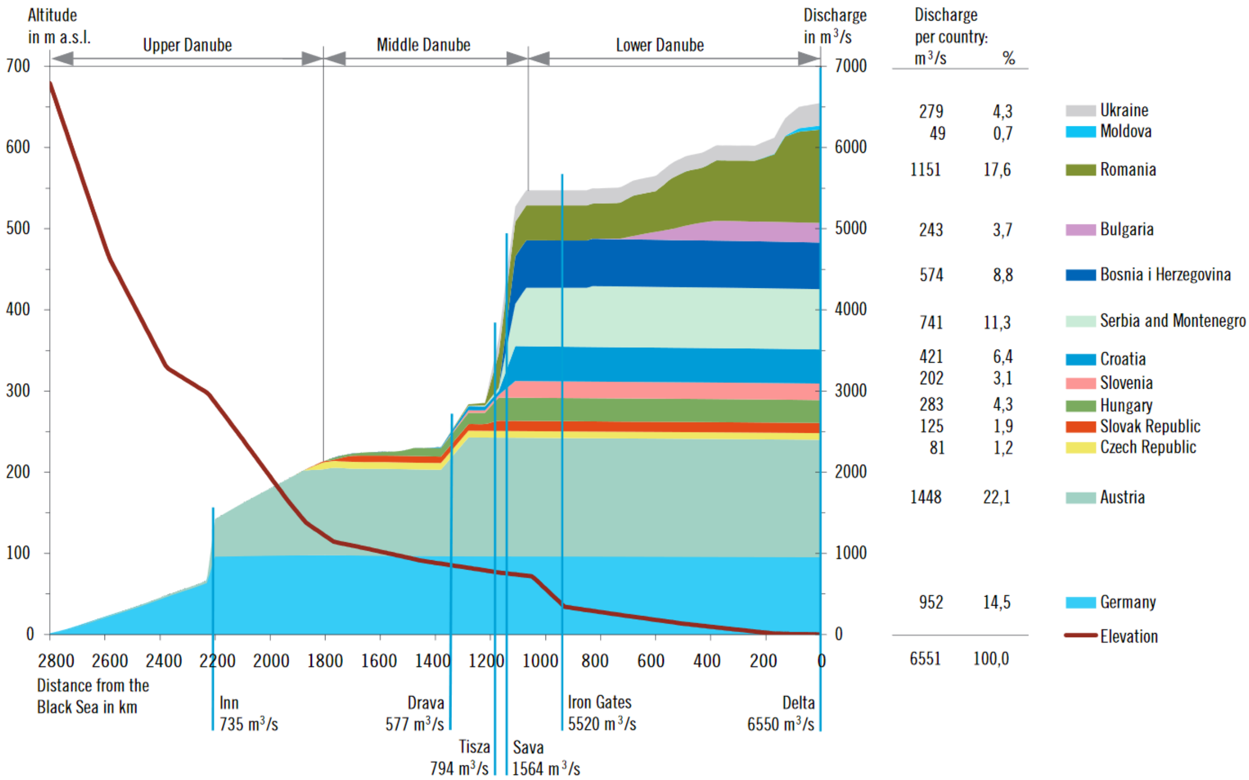


Fig. 1. 23 – Longitudinal profile of the Danube River and contribution of water from each country (in %) to the cumulative discharge of the Danube (in Mio m3/year), 1994-1997 period [13]

	January	February	March	April	May	June
Q maxim (mc/s)	5000	5500	8000	8000	7500	11000
Q average (mc/s)	3700	4700	6000	6000	6000	9000
Q minim (mc/s)	2800	3800	4000	4700	4800	7000

July	August	September	October	November	December
6200	4500	3000	3000	4000	5500
5000	3500	2600	2400	3000	4000
3800	2700	2300	2200	2500	2800

Table 1. 4 – The maximum, average and minimum flow of the Danube River of every month - 2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Multiannual mean (m^3/s)	4950	5300	6700	7900	7250	6400	5350	4300	3800	3850	4650	5200

Table 1. 5 – Multiannual average debit [14]

In June 2019 the hydrological regime had values above the monthly multiannual averages (Table 1.5).

1.5. Object trajectory simulations

The technology for predicting particle trajectories in the sea can be used in a variety of ways. For example, it can provide a method to track objects in the sea during an emergency situation from the last known time and location data. It also presents the possibility of tracing pollutants in the event of an oil spill accident. In this study, MOHID numerical model was used to simulate five sources of waste and how will the waste travel from a specific spot in a period of six days along the coast. The five sources were selected mainly in Mamaia Bay, Constanta at different distances from the shore and along the coast, as the direction of the currents is influenced by the bathymetry and the shape of the coast.

The study area and the trajectories of the five “objects” are presented in the figure below (Fig. 1.24). The deployment spot is marked by the red-yellow pins, and the solid red lines represents their trajectories. The time span is from October 12, 00:00 AM (local time) to October 18, 06:00 AM.

- The trajectories of the first two simulations are the shortest as they are closer to the shore and the direction of the current “push” the waste to the shore.
- Note that the third simulation is also in the bay area, but due to the current flow pattern the waste is thrown out of the bay and pushed to the north in the first days of the simulation and then to the south with the main current flow.
- The last two trajectories, 4 and 5 have an almost similar result, as they are farthest away from the shore and are subjected to the main current flow.

Thus, due to the shape of the shoreline but mainly to the dikes of the northern port of Midia Navodari, the waste lost at sea will pass over the bay. If the wind would blow from the east or the current flow from the south east, there is a chance that the marine litter would find its way onto the shore.

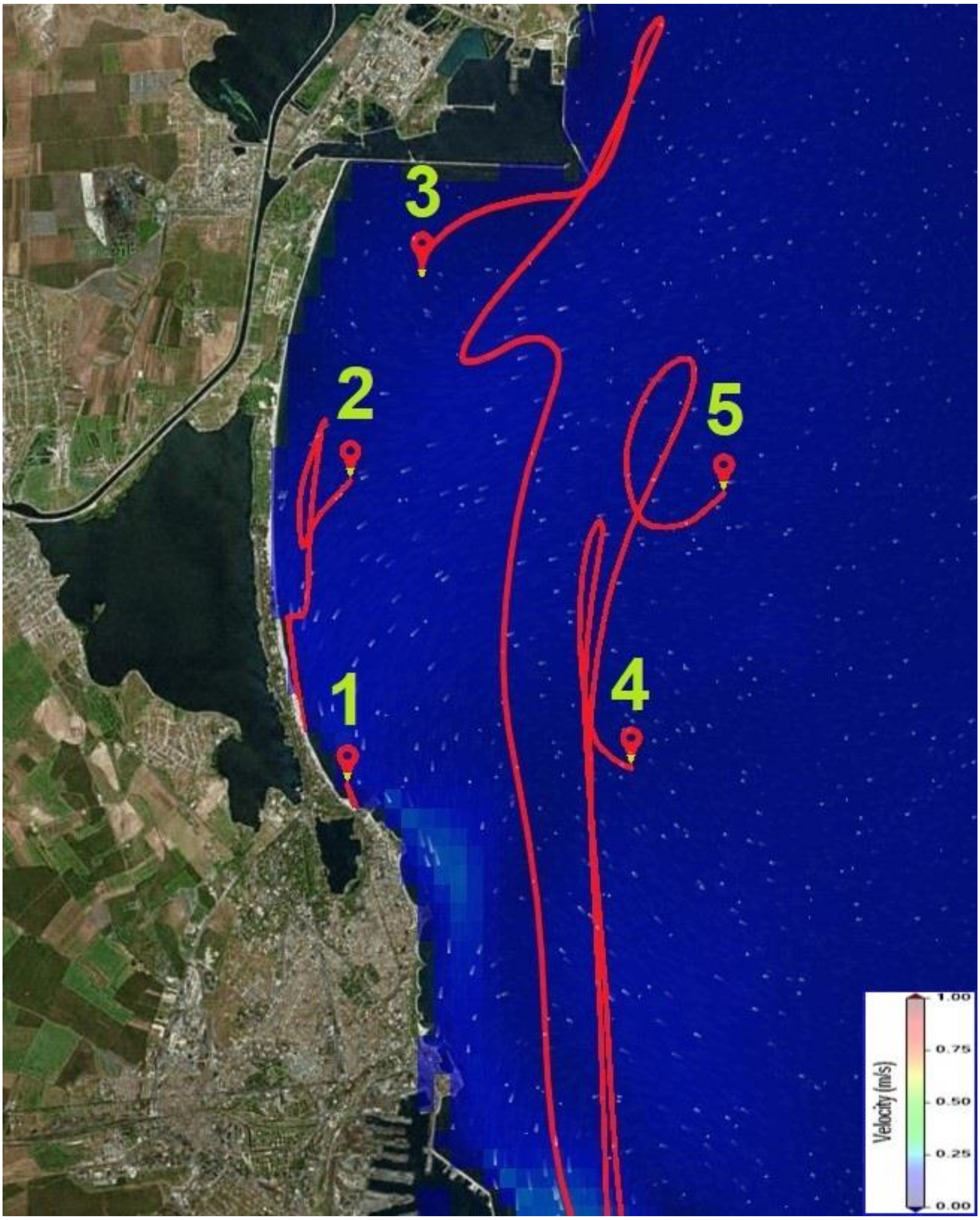


Fig. 1. 24 – MOHID numerical model object trajectory results

1.6. Waste streams

Regarding the stream of waste, they are non-existent on the Romanian coast. The quantities of marine waste that occasionally reach the coast are brought by the storm surges and the wind blowing in the direction of the shore. Once the storm drops in intensity, the waves fade and the sea level is reduced, leaving behind the so-called "storm surge limit", which consists of all sorts of objects (shells, snails, algae and marine waste). that the sea brings to the shore, and generally this limit has a width between 1-5m. Since the southern coastal area is made up of mostly arranged beaches, they are regularly maintained, either by the Dobrogea-Litoral Water Basin Administration or by the companies responsible for managing the beach sectors. Marine waste is most commonly encountered in the northern sector of the Romanian coast, which is largely made up of the Danube Delta Biosphere Reserve, which makes the coastline almost inaccessible. The northern coastline cannot be mechanically cleaned as it is done in the southern sector, manual cleaning campaigns are required, especially towards the end of Sahalin Island, where the soil is unstable (Fig. 1.25) (consisting of dead vegetation and sand).

Fig. 1. 25 – Marine waste on the Sahalin Island

2. Part Two - Study of the current state of a selected area of the Black Sea and of the types and distribution of waste in it (Romania)

2.1. Pressures on marine environment and possible polluted areas

A wide range of human activities may affect the marine environment. Several regional seas conventions have developed a significant list of activities, and some of them may have a bad effect on marine habitats and species.

Examples of possible human activities and their effects;

Human activities

- ConstructionsȘ coastal and sea, including pipelines, oil facilities and wind farms;
- Exploration and extraction of mineral resources: oil and gas, sand, gravel;
- Transport, navigation, transport infrastructure;
- Pollution: Pollution liquids: chemical, nuclear, biological; organic waste and minerals;
- Fishing, Aquaculture;
- Activities military maneuvers, research, waste;
- Tourism, recreational boating and marine sports.

The effects of human activities:

Physical

- Destruction and fragmentation of habitats;
- Removing and substrate modification, turbidity etc;
- Disposal;
- Noise pollution;
- Visual pollution;
- Changes in water temperature, salinity, currents etc;

Chemical

- Contamination with organic compounds: eg. pesticides; heavy metals, hydrocarbons, nuclear waste;
- Increasing organic matter, nutrient changes: coastal urban waste water, waste from rivers polluted drainage from agricultural activities, eutrophication etc.

Biological

- Extermination of target species and non-target;
- Injury bodies that can subsequently cause death or inability to reproduce;
- Driving, burial, emersions species not mobile;
- Introduction of pathogens;
- Changes in population: structure and / or dynamic;
- Introduction of genetically modified organisms.

In this respect, Romania has recently issued Order 19 of 2010, the Ministry of Environment and Forests for approval methodological guide on proper assessment of the potential effects of the plans and projects on protected natural areas of community interest.

Human activities in marine Natura 2000 sites are regulated by the same command of Directive "Habitats" in terms of land area. Article 6 of Directive "Habitats", it applies where there is the likelihood that influences of an activity or a combination of activities is significant.

Commission Communication to the Council and European Parliament of 24 October 2005, "Thematic strategy on the protection and conservation of the marine environment" is also a relevant reference document identifying the various pressures on the marine environment.

Related pressures include commercial fishing, oil exploration and gas transportation, storage in the environment of substances and nutrients that are harmful and hazardous, discharge of waste, including the dumping of contaminated dredged sediments, noise submarine and physical degradation of habitats due the dredging and extraction of sand and gravel.

In general, the most important source of waste is the land where everything is made, but at the Romanian coast there are several sources. In the northern part, the Danube River brings most of the waste, as most European rivers will end up eventually in it. Of course, there are several other possible sources of pollution (be it chemical products or waste water) along the coast, mainly found in the harbors or around them (Table 2.1).[12]

Domestic, pluvial and industrial wastewater from economic agents are collected in the sewerage network (with a length of 0 709.155 km) and discharged into the Black Sea after being treated in the two wastewater treatment plants of Constanta municipality: Constanta North and Constanta South.

In the northern part of Mamaia resort, the waters resulting from the technological processes specific to the petrochemical plant are subjected to the physical processes of separation and decanting in a series of pre-treatment stations located inside the technological installations, subsequently being evacuated to the final treatment plant.

The final treatment plant collects and treats the industrial waters resulting from the Petromidia Rompetrol refinery, the Midia Thermoelectric Power Plant, Petromar and the wastewater of the city Navodari. The final treatment plant is composed of three stages, mechanical-chemical, biological and a secondary biological (biological self-purification) stage. The treatment plant was designed for an average flow of about 1880 l/s. The treated water is then discharge into the Black Sea through the Buhaz channel.

The Constanta North treatment plant serves the northern part of Constanta and the Mamaia resort. It was completely rehabilitated by demolishing the old one, with a much smaller capacity. The new capacity is 1920 l/s. The station is equipped with tertiary gear, with extended aeration, technology for removing nitrogen and phosphorus. The evacuation of the treated wastewater is done in the Black Sea, in the fishery area at the isobath of -15 m through a pipe with the length of 3860 m and through a short pipe with the length of 493 m on the isobath of -3.5 m (only for emergency situations).

The Constanta Sud treatment plant has a maximum capacity of 3200 l/s. It is located in the southern part of the city near gate 6 of Constanta Port. It takes over and purifies urban, industrial and pluvial wastewater from most of Constanta through its mechanical-biological treatment plant with the tertiary gear. The evacuations are done gravitationally in the harbor, berth 86.

Possible sources of pollution	**Location**
Petromidia Refinery	Black Sea – through the Buhaz Canal
Maritime Port Administration - Midia Port	Black Sea – Port Midia
Naval shipyard Midia Navodari	Black Sea – Navodari - Port Midia
Midia Marine Terminal	Black Sea – offshore, floating terminal with buoy located 8.5 km from shore
Midia Navodari thermoelectric plant	Black Sea – Petromidia
RAJA Constanta NORD - Communal household	Black Sea – Fishery area - 3.5m / 15m isobath
RAJA Constanta SUD - Communal household	Black Sea – pier 86
Maritime Port Administration – Constanta Port	Black Sea – pier 79
Oil Terminal	Black Sea – pier 69
Constanta Naval Shipyard	Black Sea – Domestic and technological wastewater that requires purification reaches the sewage network
RAJA Constanta - Eforie SUD - communal household	Black Sea – 10m isobath, near the Eforie Sud resort
RAJA Constanta - Mangalia - communal household	Black Sea – Mangalia outpost area near the treatment plant
Maritime Port Administration - Mangalia Port	Black Sea

Table 2. 1 – The main potential sources of pollution at the Romanian coast [12]

Another source of potential pollution is the Constanta port. It is located on the west coast of the Black Sea and is administered by the Maritime Port Administration of Constanta. From the specific activities carried out in the port, there are domestic, meteoric and bilge water from ships. The wastewater treatment plants are comprised of: bilge water treatment plant, mechanical pre-treatment station, wastewater treatment station, domestic wastewater treatment ministries and leachate treatment station. The mechanically and biologically purified waste water is discharged to the harbor area at berth 79.

Moving further to the south the Eforie South treatment plant receives domestic waste water and a part of the industrial water from the economic agents that are collected in the sewerage network, that has a length of 284.63 km (from the localities Eforie Sud, Nord, Agigea, Schitu, Tuzla and Costinesti). The treated water is evacuated in the Black Sea after they were and treated in the Eforie Sud treatment plant. The treatment plant has a capacity of 745 l/s in the summer time, respectively 322 l/s in the rest of the year. The technological scheme of the treatment plant is comprised of two steps, one mechanical and one biological, with nitrification - denitrification and reduction of phosphorus content. The discharge pipe ends in the Black Sea, the pipe has a length of 1350 m and stops on at the -10m isobath, the end of the pipe is fitted with a dispersion system.

The last treatment plant in the south is at Mangalia. There, the domestic waste water and a part of the industrial water from the economic agents are collected in the sewerage network (with a length of 170.7 km) and are discharged into the Black Sea after they have been treated. It serves the municipality of Mangalia and the tourist resorts in the area, respectively Olimp, Neptun, Jupiter, Venus, Aurora and Saturn and is located in the southern area of Mangalia.

Mangalia treatment plant has a capacity of 740 l/s and mechanically and biologically treats wastewater, with the removal of nitrogen and phosphorus through two internal mud recirculation's. After the waste water was been treated it ends up in the Black Sea in the harbor area of Mangalia, near the station, the purified water being evacuated through a pipe of 1200 mm at 4 m at sea, at a depth of -2.50 m. The new waste water pipeline was completed and is in the reception period.

The Maritime Port Administration also cleans the water surface in the harbor, collecting tons of waste every year (Table 2.2). The situation has improved over the years and it will continue to improve as people get aware of the situation.

No.	Year	Quantity (tons)
1	2014	22
2	2015	13
3	2016	14
4	2017	7
5	2018	10
6	2019 Jan - July	12

Table 2. 2 – Waste from the surface of the water (depollution of the port basin) Waste code: 15 01 10

The load of substances from punctual discharges can be calculated by knowing the concentrations of the substances at the source of discharge and the flow of water, the emissions of substances from diffuse sources cannot be measured. For small watersheds the loads can be estimated but for medium and large river catchments the estimation of the diffuse source pollution is only possible by mathematical modelling. This is done using land use, hydrological, soil and hydrogeological data collected in a Geographical Information System (GIS) as well as statistical information for different administrative levels. The definition of significant sources of pollution for the diffuse emissions is a very complex theme. This is especially the case for large transboundary river basins such as the Danube. The main problem is to distinguish between areas with low and high levels of diffuse pollution. These levels are not only dependent on anthropogenic factors such as land use and land use intensities, but also on natural factors such as climate, flow conditions and soil properties. These factors influence the pathways of the diffuse nutrient emissions, retention and losses on the way from the origin to the inputs into the river system. Absolute values of the significant diffuse source of pollution are also difficult to define. This is because the level of the intensity of land use as the main indicator for the diffuse emissions into the river is also dependent on the population density in the catchment area. Criteria for estimating the significant diffuse sources, which ignore the natural and basic anthropogenic conditions, are not reliable for distinguishing between significant and insignificant levels. Therefore, a number of uncertainties need to be taken into account when analyzing the data.

The total nutrient point discharge into the Danube was about 134.2 kt/a nitrogen and 22.7 kt/a phosphorus in the year 2000.

The difference between the two figures present the state of the specific nutrient point source discharges within the Danube countries (Fig. 2.1). For these figures the estimated point discharges of nutrients for the individual countries were divided by the population in the countries, which is connected to sewer systems. For nitrogen it is shown that the lowest point N discharges are in Germany with 4 g/(Inh.·d) per connected inhabitant followed by Austria, Ukraine and Moldova.

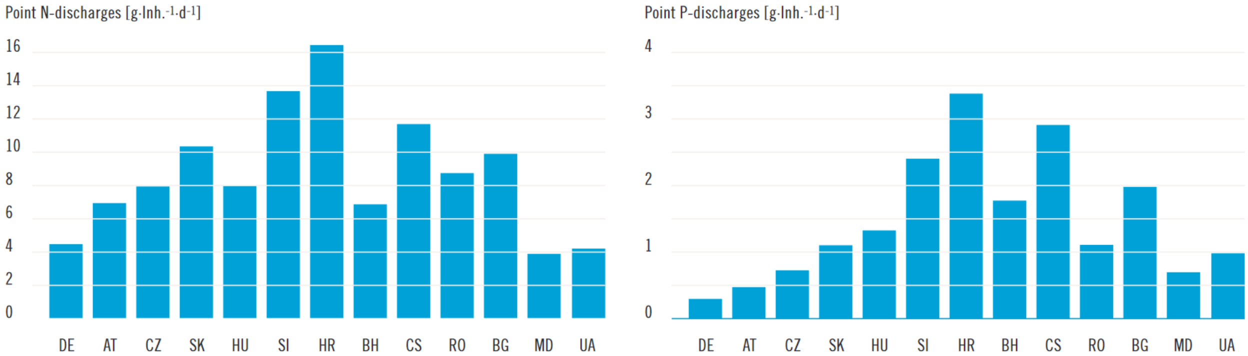


Fig. 2. 1 – Inhabitant-specific N discharges from point sources (total load divided by total population in the state) in the Danube countries for the period 1998 to 2000

2.2. Marine waste

2.2.1. The Danube River plastic pollution

These variations were mostly explained by events of dry and wet weather, implying that runoff plays an important role in the transport of plastics into freshwater systems. In recent years, more studies sampled plastic in surface waters of rivers. In Europe, studies estimated that the Danube River releases 530–1500 tons of plastic into the Black Sea annually. [15]

The highest number of microplastic litter particles, 2 trillion (2E+12) microplastic particles are transported annually by the River Danube to the Black Sea. One of the possible reasons for such a high number of particles could be the weather conditions during the sampling period. Because of a thunderstorm in the Siret basin, the Danube carried temporarily a lot of litter resulting from the plastic litter being washed from the floodplains into the river and carried further downstream. Another reason could be the fact that the Danube River basin contains a population of 81 million of people. The Danube is estimated to transport 500 tons of plastic litter to the Black Sea annually.

The types of litter found in rivers varies. The most diverse samples were collected in the River Danube, covering 39 categories under the TSG2 categorization (Table 2.4).

The analysis of daily variability of litter types shows that in all the daily samples, artificial polymer material (plastic) was nearly always the most abundant material. Other materials found in river are rubber, chemicals (G213, paraffin wax), metal, cloth/textile, glass and ceramics, processed and worked wood, and paper and cardboard.

The monitoring location was in Galati, about 190 km from the mouth of the main branch of the Danube in the Black Sea. That location is upstream of the large Danube Delta with several parallel branches. A marina was selected as the final monitoring site on a left bank of the river (45°25'2.76"N; 28° 2'6.67"E). The location is downstream of the Siret tributary and upstream of the center of Galati.

Plastic micro particles were counted in samples from 5 consecutive sampling days. The average numbers of micro particles that were caught by manta net in river are between 100 –800. The average maximum number of microparticles per km^2 found in the Danube is ≈ 1 million/km^2). [16]

Manta trawl	Number of particles		Weight of particles (g)		Nr / km^2		g / km^2	
	Average	STDEV	Average	STDEV	Average	STDEV	Average	STDEV
Danube	381.6	245.70	0.0449	0.0529	1061126.2	530066.4	116.2	133.49

Table 2. 3 – Statistical parameters

More than 74400 small particles (Table 2.1) of size from 5.1 mm to 52.7 mm, were shown to be floating per km^2 in an average sample. Among four categories (fragments, pellets, foams and fibers) that were used for microparticles (<5 mm) categorization, fibers were the most abundant in the river.

Danube		TSG_ML General Code	General Name
A	B		
x	x	G3	Shopping Bags incl. pieces
x	x	G10	Food containers incl. fast food containers
x		G12	Other cosmetics bottles & containers
x		G20	Plastic caps and lids
x		G21	Plastic caps/lids drinks
x		G24	Plastic rings from bottle caps/lids
x	x	G25	Tobacco pouches / plastic cigarette box packaging
x		G27	Cigarette butts and filters
X		G28	Pens and pen lids
x	X	G30	Crisps packets/sweets wrappers
x		G32	Toys and party poppers
x		G34	Cutlery and trays
x	x	G38	Cover / packaging
x		G45	Mussels nets, Oyster nets
	x	G50	String and cord (diameter less than 1cm)
x	x	G67	Sheets, industrial packaging, plastic sheeting
x		G71	Shoes/sandals
x	x	G74	Foam packaging/insulation/polyurethane
x	x	G78	Plastic pieces 0 -2.5 cm
x	x	G79	Plastic pieces 2.5 cm > < 50cm
x	x	G81	Polystyrene pieces 0 -2.5 cm
x		G82	Polystyrene pieces 2.5 cm > < 50cm

	x	G83	Polystyrene pieces > 50 cm
x	x	G89	Plastic construction waste
x		G90	Plastic flower pots
x	x	G95	Cotton bud sticks
x		G99	Syringes/needles
x		G112	Industrial pellets
	x	G124	Other plastic/polystyrene items (identifiable)
	x	G133	Condoms (incl. packaging)
	x	G142	Rope, string and nets
	x	G145	Other textiles (incl. rags)
x		G152	Cigarette packets
	x	G156	Paper fragments
x		G159	Corks
x		G178	Bottle caps, lids & pull tabs
x		G200	Bottles incl. pieces
x	x	G213	Paraffin/Wax
x		G216	Various rubbish (worked wood, metal parts)
32	20	Sum	

Table 2. 4 – Presence of categories in different types of samples (surface net(A), suspension net (B) (Legend: yellow - artificial polymer material, blue - rubber, orange - cloth/textile, light green -paper/cardboard, dark green - processed/worked wood, grey - metal, light yellow - glass/ceramic, uncolored – unidentified) [16]

Comparison of the content of plastic materials for all plastic categories collected in the Danube River, shows that polyethylene (PE) is the most prevalent material, second most prevalent material is polystyrene (PS) and the third Nylon-PA (Fig. 2.2). [16]

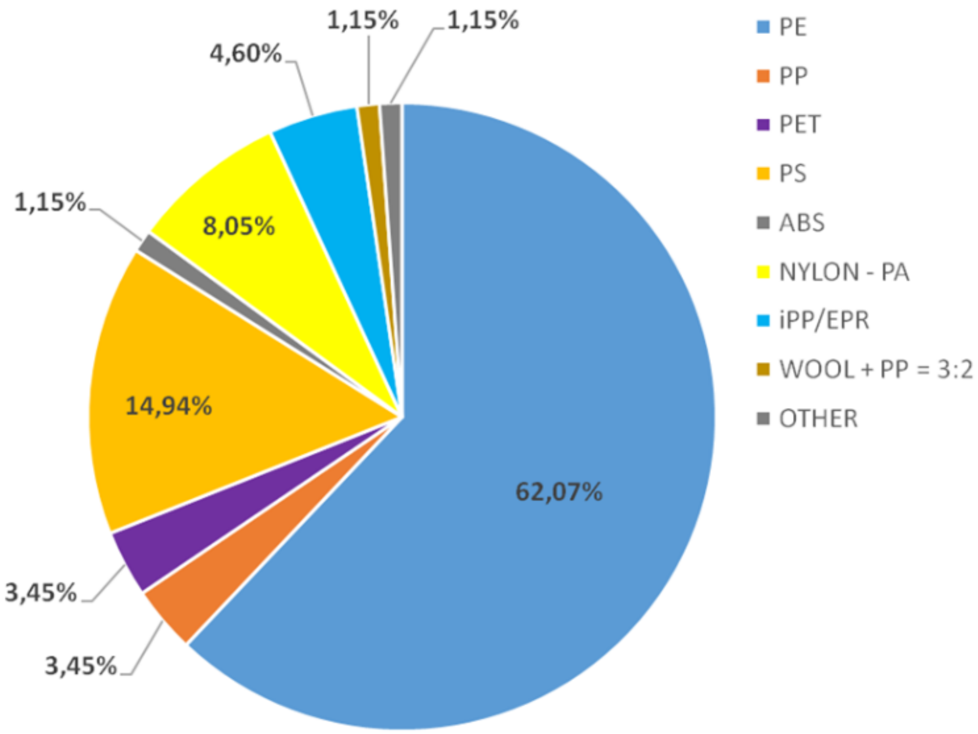


Fig. 2. 2 – Content of Plastic Material in Danube River [16]

2.2.2. Bottom sea waste

The fishing activities carried out on the Romanian coast of the Black Sea during the period 2016-2017, for the assessment of the status of the populations of demersal fish, respectively mollusks, have facilitated the collection of waste existing at the bottom of the sea in all the areas where there have been trawling's on the Romanian coast, at depths between 13-63 m. According to the methodology used worldwide, for such activities fishing equipment is used, known as bottom trawl and dredge. For the collection of waste existing on the seabed, NIMRD Constanța continued to use both the bottom trawl 22 / 27-34 m, as well as a new type of tool - beam trawl (specialized dredge for mollusk harvesting).

Expeditions by sea were carried out both with the research vessel "Steaua de Mare 1", which used the variant of bottom trawl 22 / 27-34 m, designed and made within the NIMRD Constanța, as well as with vessels of commercial companies, which used the beam type tool, which achieves a constant horizontal opening of 5 m. The duration of the trawl was 60 min, the trailing speed was maintained at a constant value of 2.5 Nd (1.286 m/s), and the horizontal opening of the tool was 13 m in the case of bottom trawl (situation in which the surface covered was 60190m^2 - 0.06 km^2). In the case of the trawl beam, the duration of the trawl was 90 min, and the trawl speed remained constant of 3.2 Nd (1.646m/s), and the horizontal opening was 5 m in the case of the trawl beam (in which case the surface covered during the trawl was 44442 m^2 - 0.04 km^2).

In 2017, four expeditions were made, two with the bottom trawl, of 10 days, in which 68 trawling's were carried out, and two with the beam trawl, of two days, in which 10 trawling's were performed. The beam trawling's were made between 17-23 m isobath in the Constanța - Periboina sector, and with the bottom trawl between 13-63 m isobath in the sector between Sulina and Vama Veche.

The total area covered by the 10 trawling's carried out with the beam was 444700 m^2, and the total amount of waste collected was 44.5 kg or, 29 pieces.
From a taxonomic point of view, the waste was categorized by metal, plastic, abandoned fishing nets, bottles and textile fabrics. The percentage situation of these wastes, of the total quantity on assortments in kg and number of pieces, is presented below (Fig. 2.3).

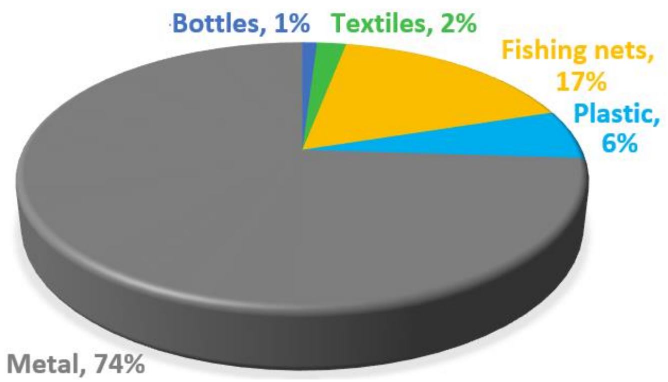


Fig. 2. 3 – Waste collected from the seabed with the beam trawl

When the bottom trawl was used, the area covered by the 80 trawlings was 4092920 m^2, and the total amount of waste collected was 162.34 kg or, 475 pieces.
From a taxonomic point of view, the waste was represented by metal, plastic, wood, bottles and textile fabrics. The weight of the waste materiales is presented as a percentage of the total quantity collected (Fig. 2.4).

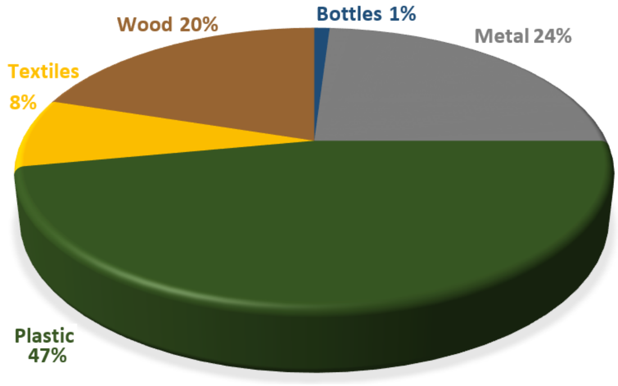


Fig. 2. 4 – Waste collected from the seabed with the bottom trawl

To be more exact, the quantity and variety distribution of marine waste, in the three areas of fishing activity on the Romanian Black Sea coast in the northern sector (Sulina - Cap Midia), the central sector (Cap Midia - Constanța) and the south sector (Constanța - Vama Veche), has undergone another analyze, to establish the degree of waste pollution in each area.

After the recorded date was processed, the quantity and variety distribution of the waste collected is as follows:

In the north sector, the activity covered an area of 1.50 km^2 taking 26 trawling's to achieve it, from which resulted a total amount of 48.68 kg waste, made out of 168 pieces. The average quantity per square meter of waste collected in this sector was about 0.03 g/m^2 of waste (Fig. 2.5).

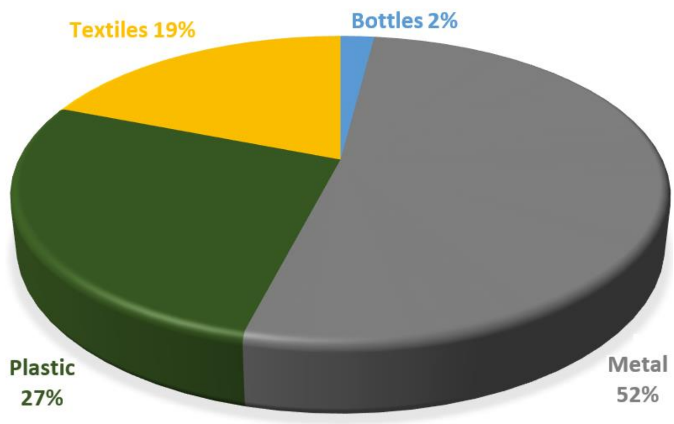


Fig. 2. 5 – Waste collected from the seabed, in the north area, with the bottom trawl

In the central sector, the activity covered an area of 1.56 km^2 taking 25 trawling's to achieve it, from which resulted a total amount of 61.06 kg waste, made out of 147 pieces. The average quantity per square meter of waste collected in this sector was about 0.04 g/m^2 of waste (Fig. 2.6).

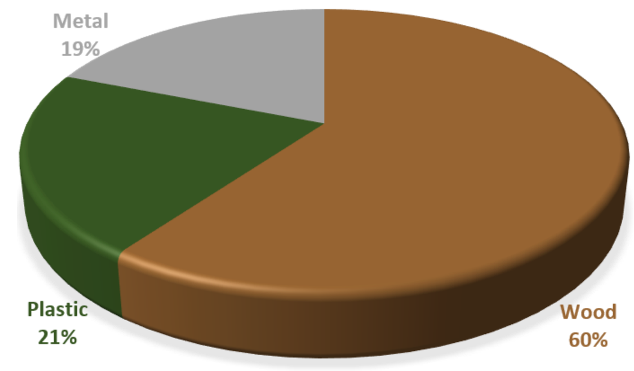


Fig. 2. 6 – Waste collected from the seabed, in the central area, with the bottom trawl

In the south sector, the activity covered an area of 1.02 km^2 taking 26 trawling's to achieve it, from which resulted a total amount of 52.6 kg waste, made out of 160 pieces. The average quantity per square meter of waste collected in this sector was about 0.05 g/m^2 of waste (Fig. 2.7).

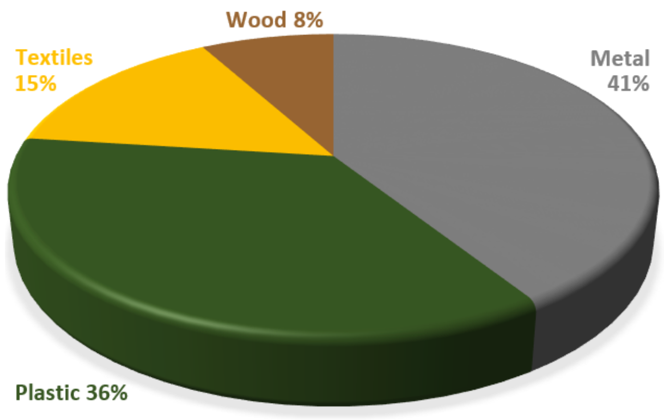


Fig. 2. 7 – Waste collected from the seabed, in the south area, with the bottom trawl

As can be seen from the graphs presented above, the most numerically representative wastes were plastic and, by weight, metal and wood respectively.

From a quantitative point of view, metallic and wood waste is more abundant during these expeditions, while numerically, plastic waste and textile fabrics are more common.

The situation is explained by the fact that the metallic and wood waste were, numerically, represented by few pieces, but with a heavier weight, while plastics and textile fabrics are more common and lighter in weight.

The largest quantities of metallic, plastic and wood waste, respectively the hard-degradable materials (plastics) were located in the areas near the ports of Constanța, Mangalia, Cap Midia and Sf Gheorghe arm, where, in fact, there is an intense naval traffic, alongside additional waste from the Danube. A big majority of the waste collected by the trawling was identified as plastic (PETs, bags, bags, linoleum, buckets, drums, etc.). The source of the plastic waste, textile fabrics, bottles, PETs, etc. is most probably from ships / boats, commercial fishing vessels, or from touristic areas during the summer season.

Approximately 80% of the waste (metal waste, textile or wood) is made by the ships that discharging it either before entering or leaving the port. Some metallic waste may originate from drilling/extraction platforms or oil and gas pipelines installation works.

Fragments of nets collected from the bottom of the sea relate to fishing gear (gillnets, trawl) lost or abandoned by the companies that practice fishing activities on the Romanian coast. However, a large part also comes from fishing gear abandoned by Turkish, Bulgarian and even Romanian vessels engaged in illegal fishing (without permits and licenses or fishing activities during the prohibition period).

The waste from wood, plastic, textile fabrics, are brought from the Danube through the three arms and carried by the currents offshore or on the shore, from Sulina to Vama Veche.

However, the composition, quantity and spatial distribution of waste at the bottom of the sea in the Romanian Black Sea sector are, however, at a level that do not present a danger to the environment and its organisms. From the data and information obtained in the field (period 2016-2017), there is even a slight tendency of quantitative decrease in waste. Thus, if in 2016 there was an average value of waste of maximum 0.22 g/m^2, in 2017, the average value of waste collected from the seabed was lower, 0.04 g/m^2.

- In the northern area 0.1 g/m^2 in 2016 and 0.03 g/m^2 in 2017.
- In the central area 0.13 g/m^2 in 2016 and 0.04 g/m^2 in 2017.
- In the southern area 0.13 g/m^2 in 2016 and 0.05 g/m^2 in 2017.

In contrast to the data obtained in 2017 with the bottom trawl, the beam trawl, averaged a value that did not exceed 0.1 g/m^2 of waste collected from the seabed, which is lower than the one registered in 2016 with the bottom trawl. It should be mentioned, however, that the beam-type tool was used 90% in the northern area and only 10% in the central area (Baia Mamaia), at shallow depths up to 23 m, where the quantities of waste are more and well represented by different varieties brought from the Danube or from the tourist areas existing on the Romanian coast.

2.2.3. Beach waste

Marine waste is any persistent solid material, manufactured or processed discarded or abandoned in the marine and coastal environment. Marine waste consists of objects that were manufactured or used by humans and were deliberately discarded or lost at sea and on beaches, including materials transported to the marine environment from land by rivers, sewer systems or winds. Mainly, marine waste consists of: plastics, wood, metal, glass, rubber, clothing, cardboard, etc. this definition does not include semi-solid residues, for example mineral and vegetable oils, paraffins and chemicals, which often contaminate the marine and coastal environment. [41]

At EU level, the Framework Directive on the Strategy for the Marine Environment (MSFD) is the mandatory legal instrument dedicated to the assessment, monitoring, setting of objectives and achieving a Good Environmental Status (GES) regarding marine waste. A group that includes technical experts appointed by Member States to support them in achieving good environmental status regarding marine waste is co-chaired by the Joint Research Center (JRC), which has developed, among others, the Guide on monitoring marine waste in the European seas and, more recently, thematic reports on the sources of waste, monitoring of waste from rivers and damage caused by marine waste.

At the regional level, there are no legal instruments specifically dedicated to the management of marine waste under the Protection Convention of the Black Sea against Pollution (Black Sea Commission). The Strategic Action Plan for Environmental Protection and Black Sea Rehabilitation (BS SAP 2009) seems to be the most appropriate regional framework for tackling marine waste issues. In this regard, a draft of the Action Plan for the management of marine waste in the Black Sea has been drafted and aims to develop a Monitoring Guide to include a chapter in the Report on the situation of marine waste in the Black Sea (the State of Environment /SoE).

In Romania, several national and regional actions have been taken to initiate and implement the monitoring of marine waste. Currently, there is no national action plan for monitoring marine waste in the Romanian Black Sea area. Adoption of the national marine waste monitoring program is being implemented. For Descriptor 10 (the provisions of MSFD D10 aim to protect the marine environment against harm caused by litter), given that the previous monitoring program provided only partially data and information on this descriptor, the values of good ecological status and environmental objectives could not be established so far. In Romania, the monitoring of marine waste has been focused more on the evaluation of beach and seabed waste, and in the future the integration of microplastic analysis of sediment (sand), water column and marine organisms is also aimed.

The evaluation criteria for Descriptor 10 are the following:

- C10.1. Characteristics of marine and coastal waste:
    - C10.1.1. Trends in the quantities of waste brought by waves and / or landfill, including composition analysis and, where possible, their source.
    - C10.1.2. Trends in the quantities of waste from the water column (including floating waste on the surface of the water) and deposited on the seabed, including analysis of the composition and, where possible, of their source.
    - C10.1.3. Trends in the quantities, distribution and, where possible, composition of microparticles (especially microplastics).

- C10.2. Impact of marine waste on biota:
  - C10.2.1. Trends in the quantities and composition of the waste ingested by marine animals (stomach contents analysis).

The status and quality of the beaches has been monitored by several institutions. Two of which (NIMRD "Grigore Antipa" and Mare Nostru NGO) released reports on the evaluation of waste on several beaches. Their main focus is the south Romanian coastal sector (from Navodari to Vama Veche) which is the most desired area for tourists to spend their vacations. Between 2015-2016, NIMRD collected data on beach waste within the European FP7 PERSEUS project, being part of the Perseur@school community. Thus, the collaboration with the European Environmental Agency (EEA) was developed, using the Marine Litter Watch App. [42]

Three beaches in Romania were included in this program: 2 beaches with sandy substrate (Ammos Blu Beach - 417 m - and Flora - 181 m, located in Mamaia resort - urban area) and 1 mixed beach (Vama Veche - 2Mai - 2323 m - in rural areas) (Fig. 2.8). Monitoring expeditions were carried out during spring (January, April) and summer. The members of the Junior Ranger Club from the Gymnasium School from 2 Mai were trained to use the application and participated in the monitoring expeditions.

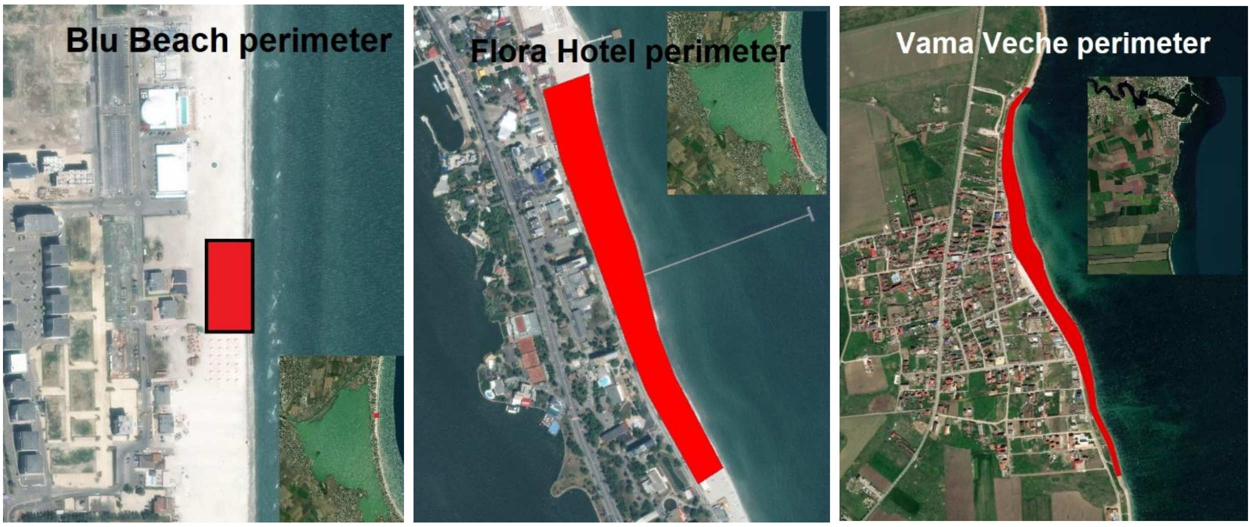


Fig. 2. 8 – Beach waste collection locations (2015-2016)

For the evaluation of beach waste, the European Commission's Guide to Monitoring Marine Seas from the European Seas (GUIDANCE ON MONITORING OF MARINE LITTER IN EUROPEAN SEAS) was used - A guidance document with the Common Implementation Strategy for the Marine Strategy Framework Directive (JRC, 2013), as well as recommendations from JRC technical reports, available online.

The beach waste monitoring was carried out on 100 m transects (Fig.2.9), covering the whole, width of the beach from the breaking line of the waves to the dry land boundary of the beach (which can be cliff, built promenade, etc.). The coordinates of the starting point and the arrival point were marked in order to guarantee the comparability of the data by monitoring the same transects.

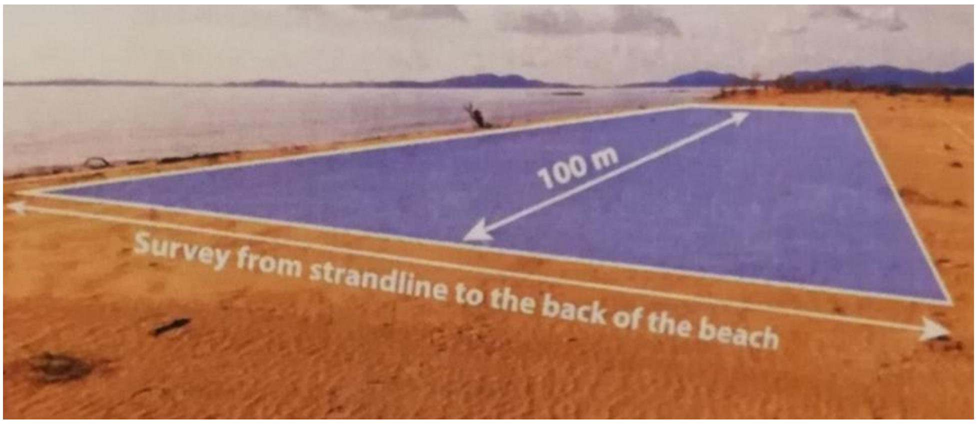


Fig. 2. 9 – Beach waste monitoring unit - length 100 m (after Vlachogianni et al., 2016)

Equipment needed: gloves, household bags, observation cards, pen, GPS phone and 3G connection (with Marine Litter Watch app installed).

Working protocol:

- The coordinates of the starting point and the final point are noted.
- The waste is collected in household bags and, after covering the entire surface, they are sorted and classified in categories, being marked with the corresponding codes, according to JRC, 2013.
- The data is noted in the observation sheet for each shipment, marking with "+" the presence of each item whenever it is observed.
- All data are centralized both in Excel format (observation sheet for each shipment / beach) and by introduction in the Marine Litter Watch app.
- When possible, weigh the large categories (plastic, rubber, textile, paper, wood, metal, glass, ceramic, chemical, unidentified).

- Finally, as far as possible, the waste is selectively packed in household bags and delivered to the authorized operators (for recycling and / or storage in arranged places).

The main categories of waste identified were cigarette butts (G27) and PET containers of different sizes (G7, G8). Higher quantities of waste were observed during the summer season, the influence of the anthropic factor being evident.
Regarding the types of material, we notice the clear dominance of artificial polymers (plastic) (over 85%), followed by metal, glass / ceramics, rubber, paper / cardboard, textiles and processed wood, in extremely small percentages. The type of waste and distribution identified on the three beaches monitored in 2015 and 2016 expressed in number of items / 100m is shown in the figures below (Fig. 2.10, 2.11, 2.12, 2.13).

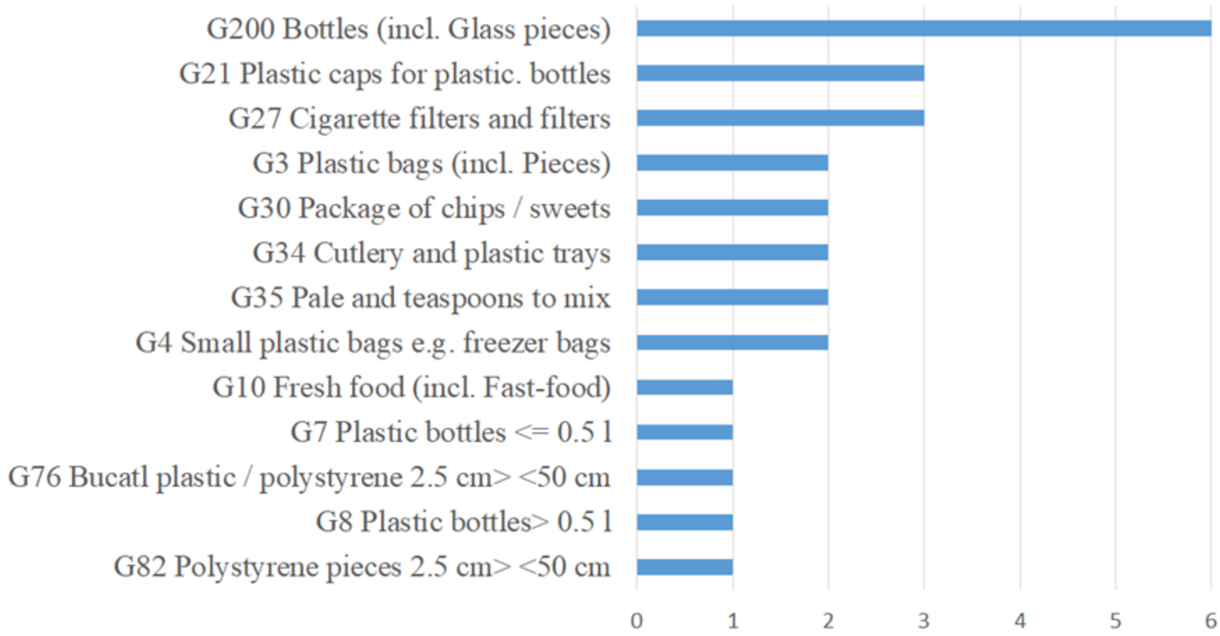


Fig. 2. 10 – Waste distribution Ammos Blu Beach, April 2015

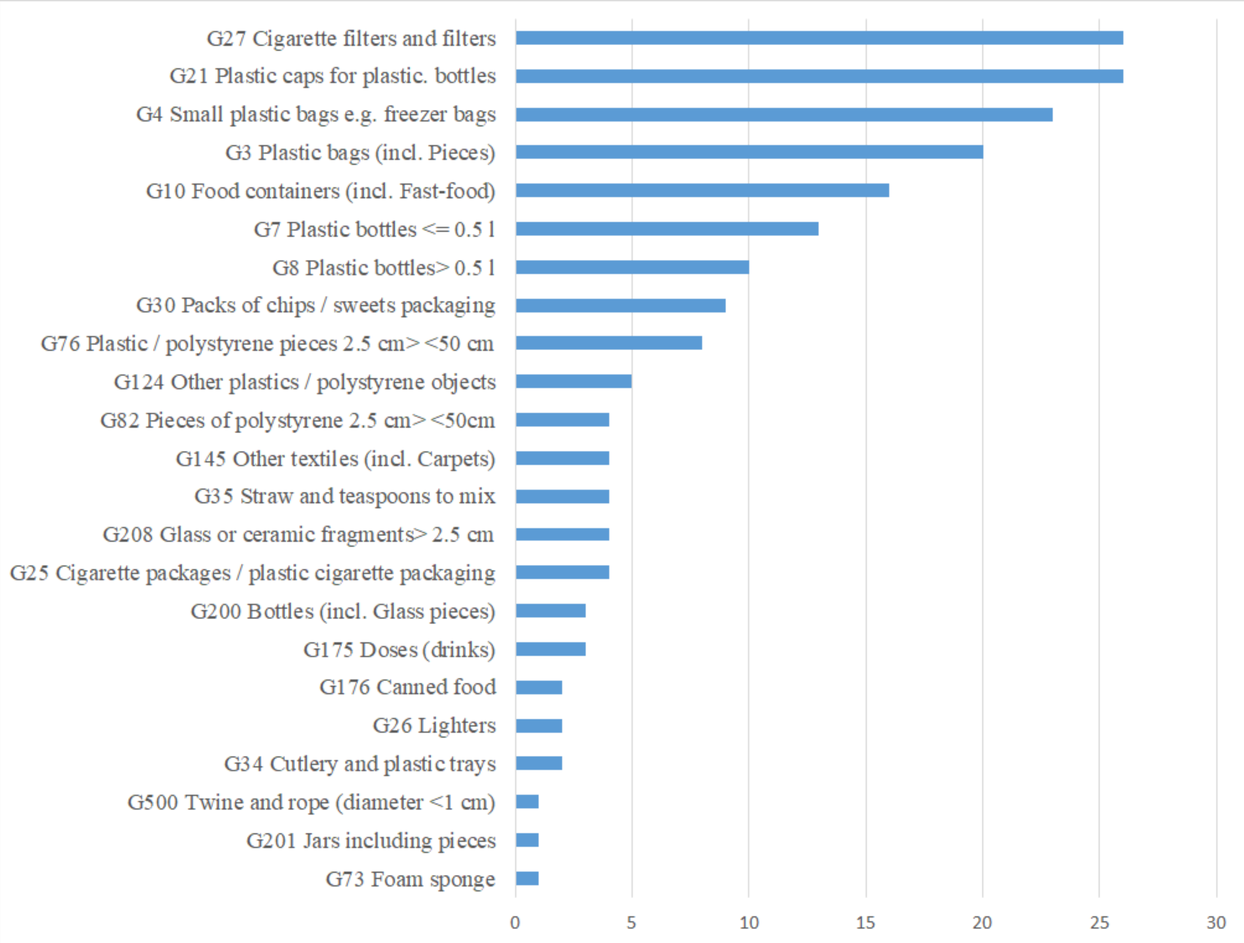


Fig. 2. 11 – Flora beach waste distribution, Spring 2015

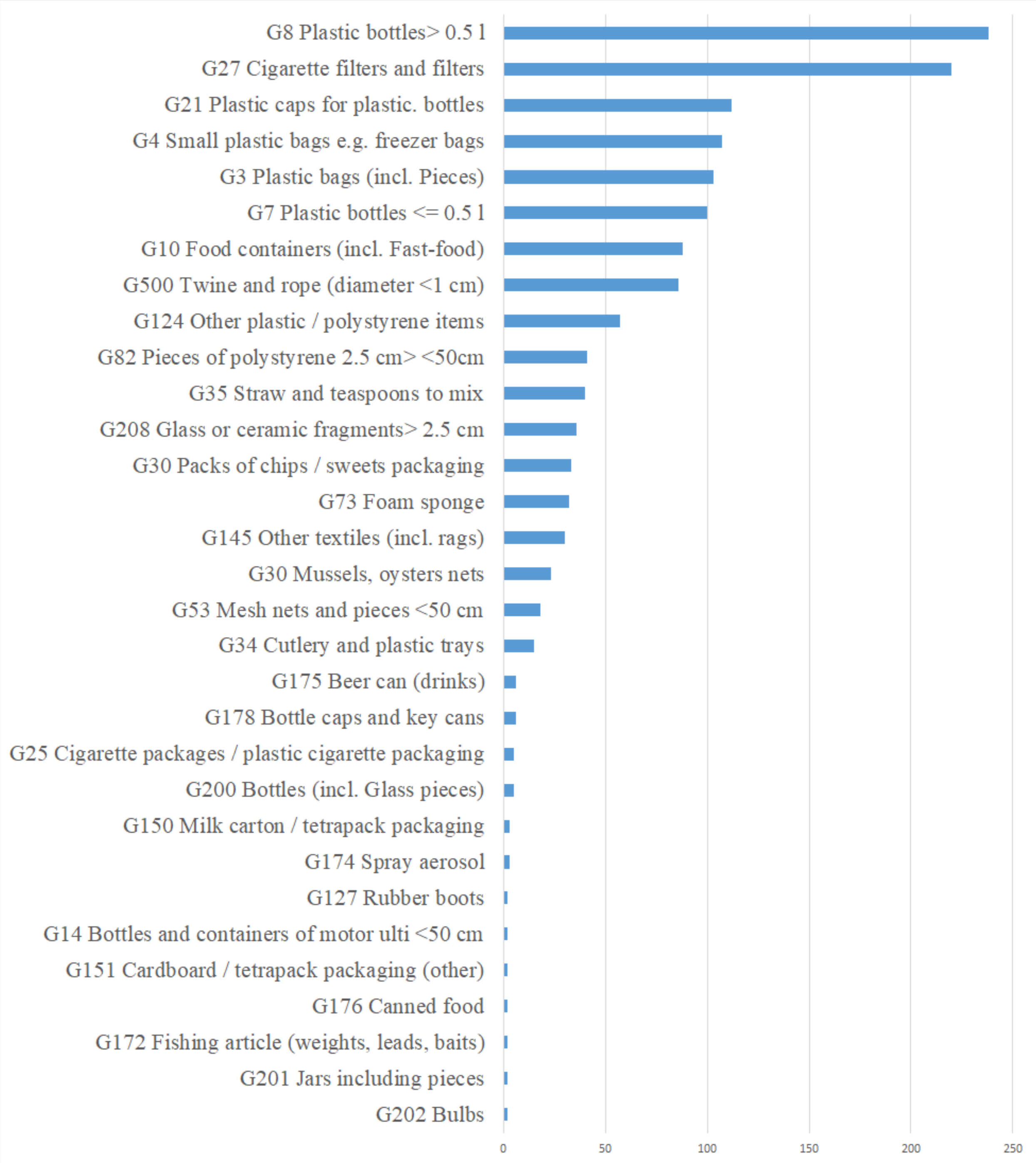


Fig. 2. 12 – Vama Veche – 2Mai beach waste distribution, 2015

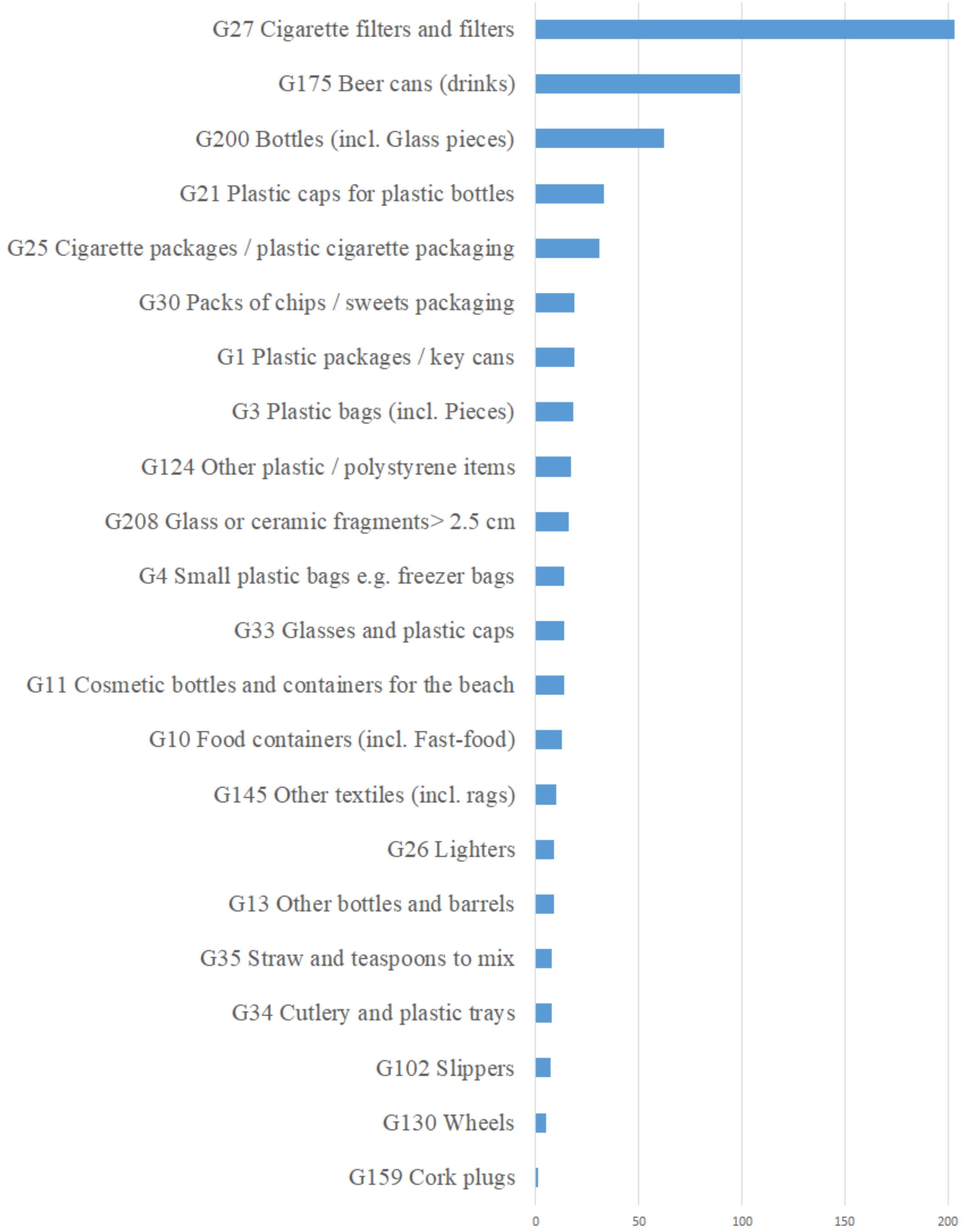


Fig. 2. 13 – Vama Veche – 2Mai beach waste distribution, 2016

Regarding the differences between the analyzed beaches, they can be explained both by the specificity of the locations (for example, Ammos Blu Beach is maintained, while the section from Vama Veche - 2 Mai is close to being a wild beach, located between the 2 localities).

The main categories of waste identified were cigarette butts (G27) and PET containers of different sizes (G7 and G8). Higher quantities of waste were observed during the summer season, the influence of the anthropic factor being evident. Regarding the types of material, there is a clear dominance of artificial polymers (plastic) (over 85%), followed by metal, glass / ceramics, rubber, paper / cardboard, textiles and processed wood, in extremely low percentages.

Results regarding distribution of waste on the coast from 2016 to 2019 show an increasing trendline.

Based on a recent report (from 2019) [34], 8 beach sectors totaling a total area of 48035 m^2 were monitored. The number of wastes items inventoried and disposed of was 12518, with 240 more than in April 2018 session, most waste registered in the Eforie sector (3889), and the least numerous in the Corbu sector (267) (Fig. 2.14). From the perspective of abundance, the waste recorded a frequency was of 0.26 waste/m^2.

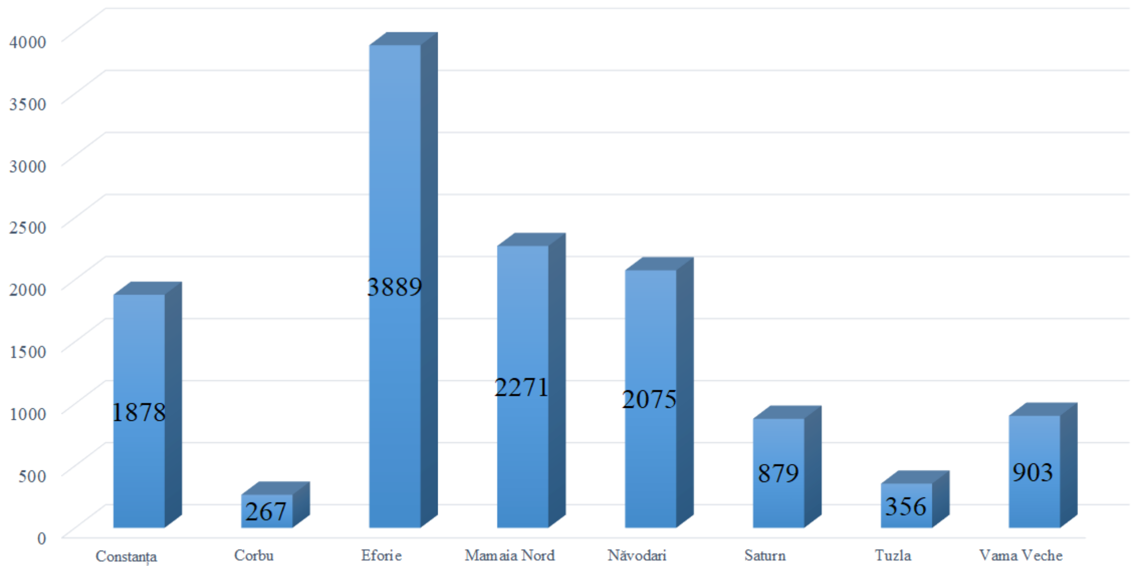


Fig. 2. 14 – The situation of marine waste on the Romanian coast 2019

Regarding the categories of waste for 2019, artificial polymeric material prevailed (7009), accounting for 56% of the total (Fig. 2.15). The least identified waste is rubber (46) and paper/cardboard (269) categories.

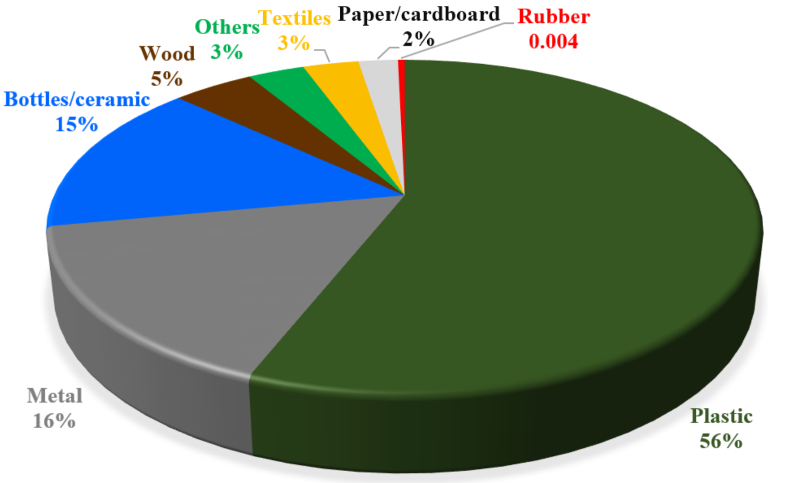


Fig. 2. 15 – Situation of waste by categories 2019

In the case of artificial polymeric material, most of the inventory items were cigarette butts, which reached the number of 1860. In addition to cigarette butts, there were numerous plastic pieces larger than 2.5 cm (966), plastic bags (929), plastic packages (841), as well as plastic caps that came from beverage bottles (376) (Fig. 2.15).

From the perspective of quantity, the waste collected summed up to 75.6 kg, plus another 20 kg waste in the form of construction materials (Fig. 2.16).

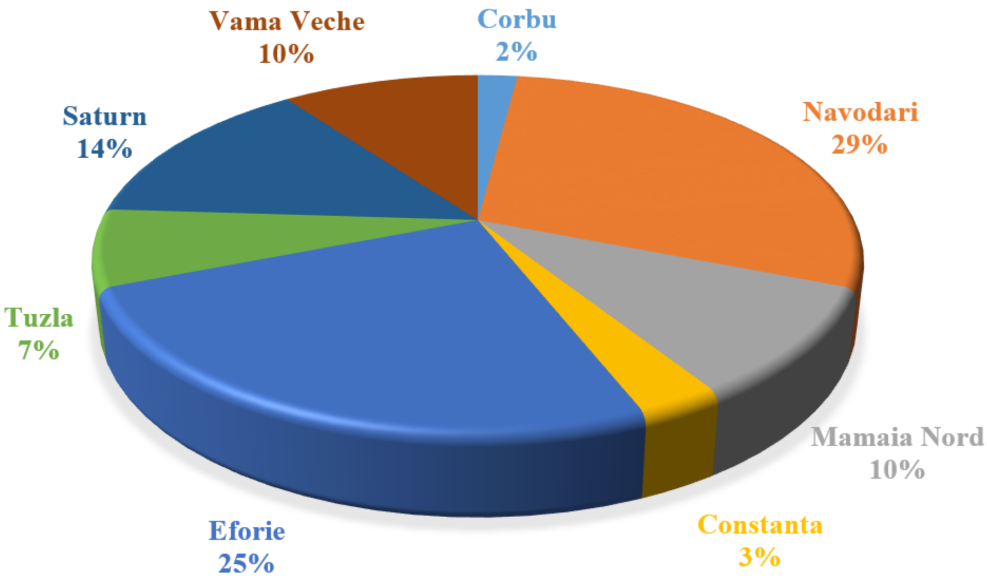


Fig. 2. 16 –Waste - by sector (kg) 2019

The number of waste items by session and categories is shown in table 2.3, where the difference between the polymeric materials that dominate the other categories can be easily observed.

Category	Apr. 2016	Oct. 2016	Apr. 2017	Oct. 2017	Apr. 2018	Sept. 2018	Apr. 2019
Artificial polymeric material	2888	23206	6799	14408	9983	19740	7009
Rubber	48	137	48	104	96	103	46
Clothing / Textiles	170	411	195	338	208	597	379
Paper / Cardboard	117	1.167	167	299	275	1342	269
Processed wood	123	453	149	681	514	640	553
Metal	171	697	781	784	692	884	2010
Glass / Ceramics	349	1042	851	1507	486	478	1868
Other	19	62	13	308	24	317	384
TOTAL	**3.885**	**27.175**	**9.003**	**18.429**	**12.278**	**24.101**	**12.518**

Table 2. 5 – Distribution of marine waste by years and categories [34]

2.3. Charting the waste collection areas and station on the coastline

Based on the available data, the following surveying areas and stations were mapped (Fig. 2.17 and Fig. 2.18)

Fig. 2. 17 – Surveyed beach areas for marine litter (from Corbu to Vama Veche)

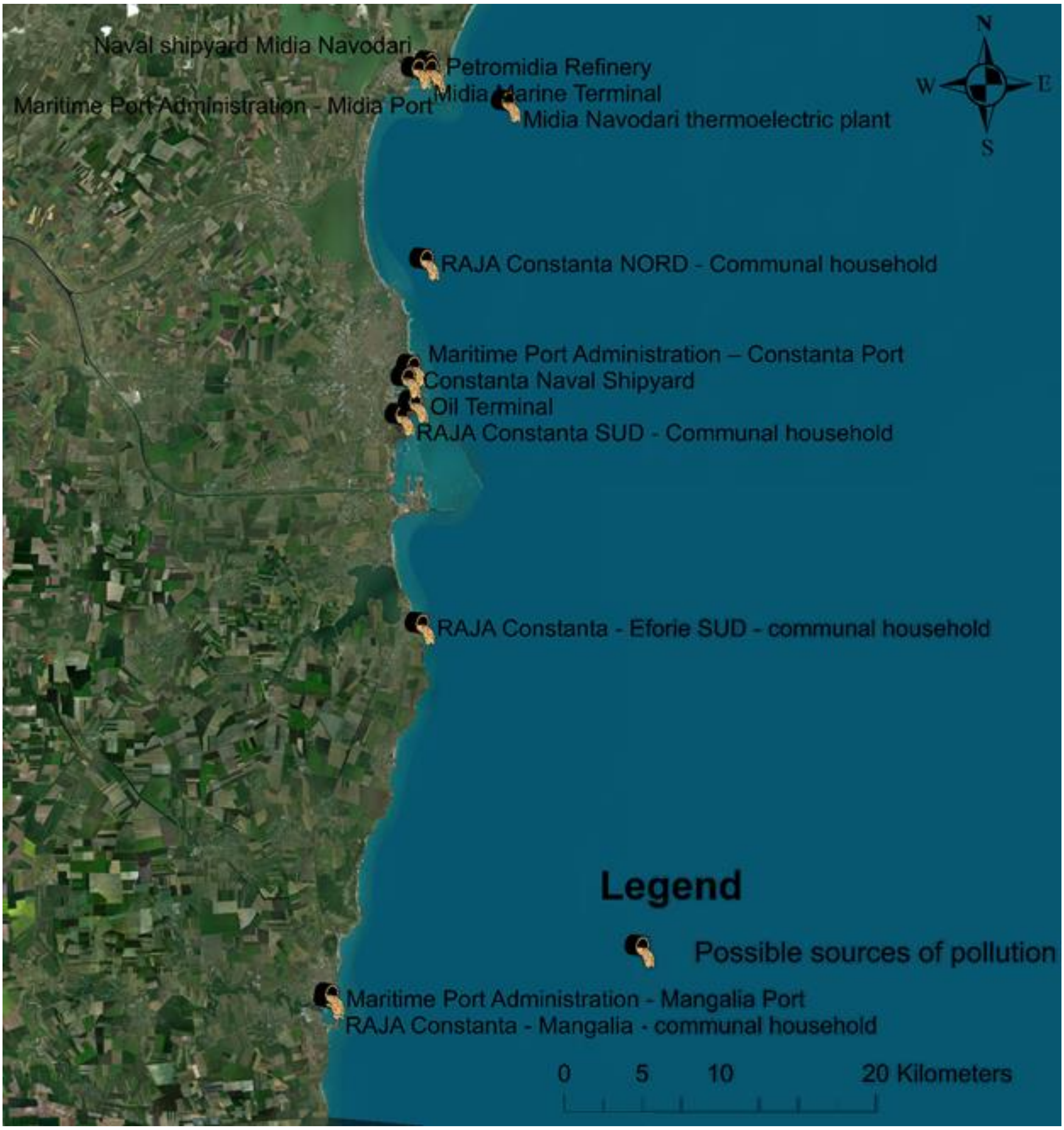


Fig. 2. 18 – Possible sources of pollution along the Romanian coast

Furthermore, in order to extract the trawling stations and their coordinates, a distribution map with the trawling zones was georeferenced, the result is shown in figure 2.19. Figure 2.20 shows the survey stations on the Romanian continental shelf.

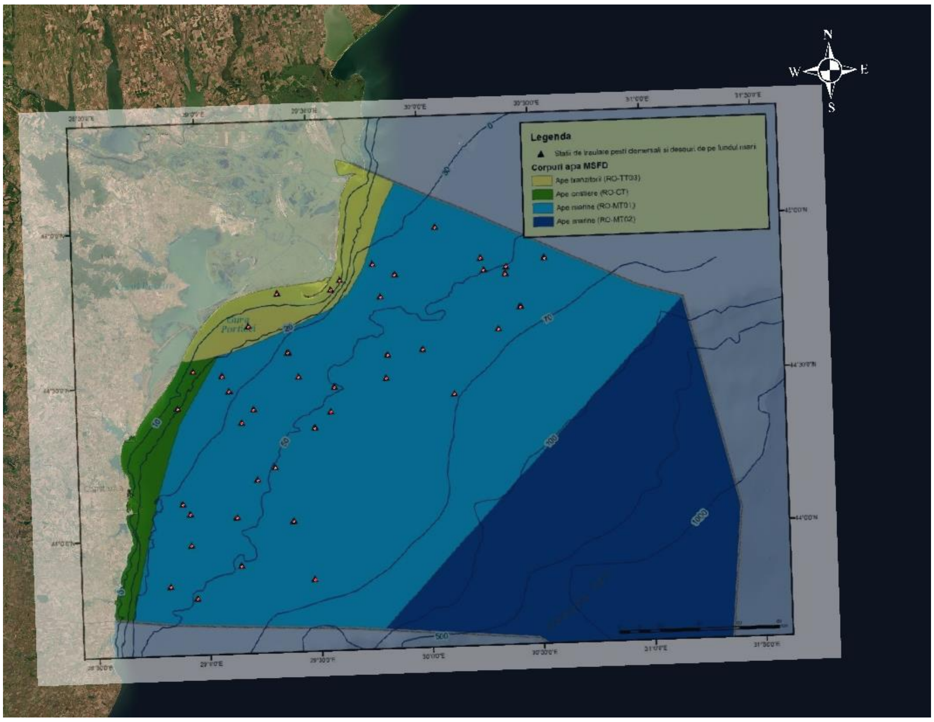


Fig. 2. 19 – The georeferenced map (result)[37]

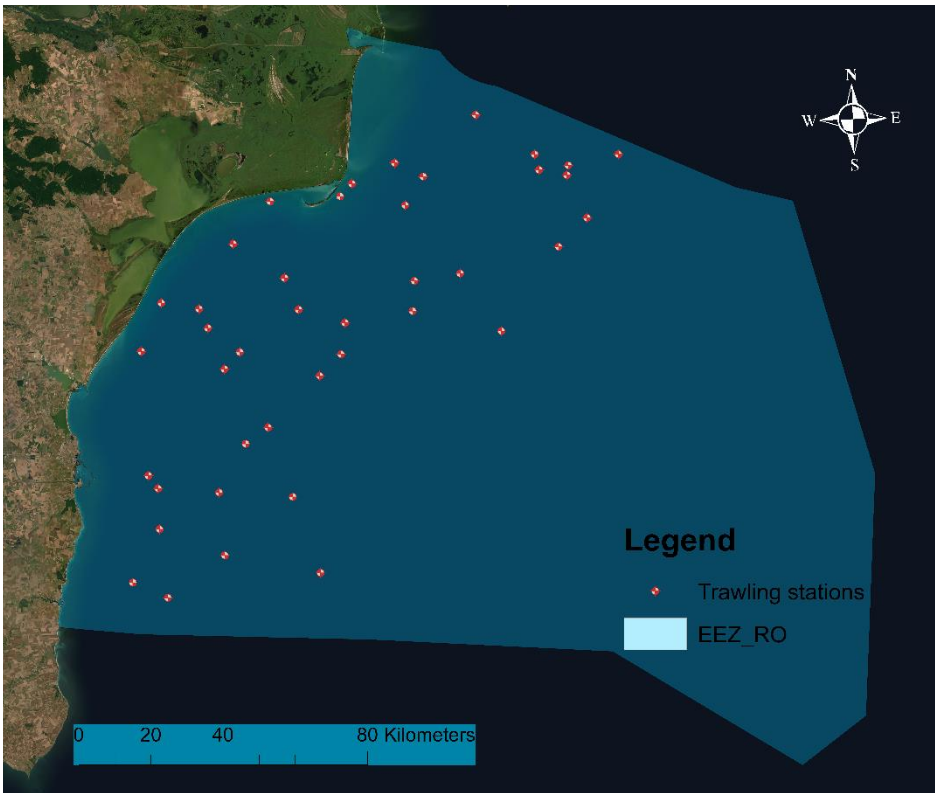


Fig. 2. 20 – Trawling stations that were used in the marine waste survey

Conclusions

From the analysis of the wind speed distribution at Constanta station, namely the 0-3 m/s class variations, it results that during the period 1952-2005 this class had a contribution generally below 40%, exceeding the limit only seven times, in the area of 40-50%. Since 2006, the contribution of low values has exceeded 45-50% of the wind speed distribution and in the last seven years the values have fluctuated around a 65-70% contribution; over the same period the contribution of values above 6 m/s was reduced to 0-2% so it can be said that there is a significant change of the wind regime in the studied area.

The global climate changes caused by the greenhouse effect are also felt on the Romanian coast. Given that both the temperature of the air and the sea water is slightly increasing, it is assumed that the increased level would be due to thermal expansion and precipitation.

According to the latest IPCC report of 2014, the water temperature in the 0-75m depth layer shows a global average freezing tendency of 0.11 (0.09 to 0.13) °C / decade so far. This tendency generally decreases from the surface in the intermediate layer, with a reduction to about 0.04 °C per decade up to 200 m, and to less than 0.02 °C per decade from 500 m depth.

Due to the continuous stream of data (1959-2017), the tendency of the water temperature in the surface layer was determined, with the slight increase by about 0.02 °C / year. Extreme weather phenomena that have been felt in the coastal area in recent years are a consequence of global warming.

Results from this study are estimates based on limited data. More research is necessary, not only on floating litter, but also on the water column and on sediments. This study shows that there is plastic litter found in the Danube River, Black Sea and on the shore. The main focus for awareness raising has been on the marine environment, not on the freshwater environment, even though it seems that most of the sources are on land. Awareness raising is to a large extent a political process, and should be promoted by the Commission, for example through the Regional Sea Conventions and international river basin authorities The most effective environmental protection measures are those that prevent inputs of pollution from the source, however, this should be combined with cleaning up existing plastics to reduce the opportunities for macroplastics to fragment into microplastics.

In order to identify trends in the quantities of waste on the monitored beaches, the average annual value of the number of wastes was calculated. There is a slight tendency to increase the number of waste (by 23.5%). A longer monitoring period (of at least 10 years), as well as increasing and diversifying the number of monitored beaches, is absolutely necessary.

In order to establish the Good Environmental Status (GES) thresholds it has been established that the quantities of microplastics in the environment should not result in harm. [43]

The aim is to achieve a statistically significant and measurable overall reduction in beach waste by 2020. Despite the natural fluctuations (annual variability, storm effects, etc.) that can affect the quantities thrown on shore and despite the local applicability and of technical feasibility, trend-based thresholds may be adequate in the absence of other methodologies applicable so as to achieve good environmental status, a general reduction with a percentage of (n%) of the number of marine waste (items / 100 m) per beaches monitored. However, to establish this percentage for the specific case of the Romanian Black Sea coast, additional data and a longer monitoring period are required.

It very important to use local data on where, how and when the types of waste are lost or thrown into the marine environment and which are the socio-economic processes that generate marine waste. These data should be the basis for discussions with key sectors that can generate or influence the generation of marine waste.

If we refer to the current data, with an increase in the number of beach waste by 23.5% from one year to the next, we can say that the good state of the environment is NOT achieved.

Regarding the waste stream or the periodicity, on the Romanian coast it would depend on the waste brought by the Danube to the sea and the occasional storms that would bring them on the shore. In the southern area of the coast the beaches are always maintained, and the areas where the waste would accumulate are non-existent because of this. In order to monitor waste streams, a certain area is needed, one where the waste is not collected in order to monitor the flow phenomenon.

This area can be found in the northern part of the Romanian coast where access is difficult or even prohibited due to the Danube Delta Biosphere Reserve.

Bibliography

1. C. Bondar, Marea Neagră în zona litoralului Românesc, Bucureşti: Institutul de Meteorologie și Hidrologie, 1973.

2. P. Gastescu, „Evolutia tarmului Marii Negre intre bratul Sfantu Gheorghe si grindul Perisor. Studii si Cercetari de Geologie, Geofizica Geografie-Geografie," Ed. Academiei RSR, vol. Tomul XXVI, p. 37 – 42, 1979.

3. E. E. Vespremeanu și D. A. Stefanescu, „Present - Day Geomorphological Processes on the Romanian Delta and Lagoon Littoral of the Black Sea," București, Analele Universității București, 1988, pp. 85-91.

4. G. Korotaev, T. Oguz, N. A și K. C, „Seasonal, Interannual, and Mesoscale Variability of the Black Sea Upper Layer Circulation Derived from Altimeter Data," Journal of Geophysical Research, vol. 108, nr. C4, p. 3122, 2003

5. Directiva 2008/56/CE a Parlamentului European și a Consiliului din 17 iunie 2008 de instituire a unui cadru de acțiune comunitară în domeniul politicii privind mediul marin (Directiva-cadru „Strategia pentru mediul marin")
6. Decizia (UE) 2017/848 a Comisiei din 17 mai 2017 de stabilire a unor criterii și standarde metodologice privind starea ecologică bună a apelor marine și a specificațiilor și metodelor standardizate de monitorizare și evaluare, precum și de abrogare a Deciziei 2010/477/UE
7. Dragos M. Niculescu, Studies concerning the evaluation of renewable energy resources in the Romanian Black Sea area, Universitatea "Dunarea de Jos" din Galați, 2019.
8. N. C. f. E. Information, „National Oceanic and Atmospheric Administration," NCEI GIS Agile Team, [Interactiv]. Available: https://gis.ncdc.noaa.gov. [Accesat 25 11 2018]
9. T. M. Cristescu, „Long-Term Caracteristics of the Wind Onshore and Offshore Western Black Sea," Cercetari Marine, vol. 45, pp. 160-172, 2015
10. T. M. Cristescu, G. Ganea, A. Niculescu, L. Buga, M. Nedelcu, D. Diaconeasa, R. Mateescu și N. D, „Wind data analysis for NIMRD's oceanographic measurement point "estacada Mamaia"," Cercetari Marine, vol. 46, nr. 4, pp. 19-30, 2016
11. Alina Daiana Spinu, Razvan Doru Mateescu, Mihaela Laurenta ALexandrov, Victor Nita; Conttributii: Luminita Lazar, Valentina Coatu, Andra oros, Oana Marin, Emanuela Mihalov, Tania Zaharia, Danut Diaconeasa, Mariana Golumbeanu, Laura Boicenco, Eugen Anton, Gheorghe Radu, Dragos Niculescu, Elena Vlasceanu (2018). CASE STUDY 1 EFORIE - COASTAL EROSION, in press, ISBN 978-606-565-131-9

12. "ROMANIAN WATERS" NATIONAL ADMINISTRATION, Raport- Date privind potentialele surse de poluare in zona Marii Negre, Nr. 16256/18.09.2019
13. ICPDR, Danube Basin Analysis (WFD Roof Report 2004)
14. INHGA, Buletin hudrologic lunar, http://www.inhga.ro/web/guest/buletin_hidrologic_lunar
15. Laurent C. M. Lebreton, Joost van der Zwet, Jan-Willem Damsteeg, Boyan Slat, Anthony Andrady & Julia Reisser, River plastic emissions to the world's oceans, 07 June 2017
16. Maarten van der Wal, Myra van der Meulen, Gijsbert Tweehuijsen, Monika Peterlin, Andreja Palatinus, Manca Kovač Viršek, Lucia Coscia, Andrej Kržan, SFRA0025: Identification and Assessment of Riverine Input of (Marine) Litter, 2015
17. Lechner, A., Keckeis, H., Lumesberger-Loisl, F., Zens, B., Krusch, R., Tritthart, M., and Schludermann, E. (2014). The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. Environmental Pollution
18. Proposal for a Directive of the European Parliament and of the Council on port reception facilities for the delivery of waste from ships, repealing Directive 2000/59/EC and amending Directive 2009/16/EC and Directive 2010/65/EU, Strasbourg, 16.1.2018 COM(2018) 33 final
19. Guidance on Monitoring of Marine Litter in European Seas, A guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive, MSFD Technical Subgroup on Marine Litter, European Commission, JRC Scientific and Policy Reports, 2013, https://ec.europa.eu/jrc
20. Mihaela Mureșan, Tatiana Begun, Cristiana Voicaru, Dana Vasile, Adrian Teacă, Beach Litter Occurrence In Sandy Littoral: Case Study – The Romanian Black Sea Coast, National Institute of Marine Geology and Geo-Ecology (GeoEcoMar), Geo-Eco-Marina 23/2017
21. Guide for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area, www.ospar.org, Edition 1.0, OSPAR Commission, 2010
22. Maria-Emanuela Mihailov, Luminița Buga, Alina-Daiana Spînu, Lucian Dumitrache, Laurențiu-Florin Constantinoiu, Maria-Ionela Tomescu-Chivu, Interconnection between Winds and Sea Level in the Western Black Sea Based on 10 Years Data Analysis from the Climate Change Perspective, Cercetări Marine, Issue no. 48, 2018
23. Relevant knowledge gathered in the framework of COLUMBUS project to address MSFD-Descriptor 10 Marine Litter, September 2017, Monitoring, Managing and Transferring Marine and Maritime Knowledge for Sustainable Blue Growth, COLUMBUS, Grant agreement n° 652690
24. Marine Litter in the Black Sea Region, The Commission on the Protection of the Black Sea Against Pollution, Istanbul, December 2007

25. Marine Litter in European Seas – Social Awarness and Co-Responsibility, MARLISCO, www.marlisco.eu (Best practices – Coaswatch Constanta)
26. Proposal for a Directive Of The European Parliament And Of The Council on port reception facilities for the delivery of waste from ships, repealing Directive 2000/59/EC and amending Directive 2009/16/EC and Directive 2010/65/EU, Strasbourg, 16.1.2018 COM(2018) 33 final
27. Final Report Marine Litter study to support the establishment of an initial quantitative headline reduction target - SFRA0025, European Commission DG Environment, Project number BE0113.000668, final version
28. The MARLISCO Guide for Reducing Marine Litter: Get Inspired and Become Innovative Through Best Practices, Marine Litter in European Seas – Social Awarness and Co-Responsibility, MARLISCO, www.marlisco.eu
29. MARLIN- Baltic Marine Litter, Final Report Of Baltic Marine Litter Project Marlin - Litter Monitoring and Raising Awareness, 2011-2013
30. Identifying Sources of Marine Litter, JRC Technical Reports, MSFD GES TG Marine Litter - Thematic Report, JRC Scientific and Policy Reports European Commision, 2016, https://ec.europa.eu/jrc
31. Moncheva, S., Stefanova, K., Krastev, A., Apostolov, A., Bat, L., Sezgin, M., Sahin, F., Timofte, F., Marine Litter Quantification in the Black Sea: A Pilot Assessment**,** Turkish Journal of Fisheries and Aquatic Sciences, www.trjfas.org
32. Top Marine Beach Litter Items in Europe, A review and synthesis based on beach litter data, JRC Scientific and Policy Reports, 2017, https://ec.europa.eu/jrc
33. Angelica PAIU, Mihaela MIREA CÂNDEA, Marian PAIU, Anca – Maria GHEORGHE Composition and Spatial Distribution of Marine Litter Along the Romanian Black Sea Coast,
34. Rapoarte privind monitorizarea deșeurilor marine în zona costieră românească, 2016-2019, Organizația Neguvernamentală Ecologistă Mare Nostrum, www.marenostrum.ro
35. EMODnet, „EMODnet Bathymetry,” [Interactiv]. Available: http://portal.emodnet-bathymetry.eu/.
36. NIMRD, National Institute for Marine Research and Development, Oceanographic Forecast. [Interactiv] Available: http://www.rmri.ro/Home/Products.Forecasts.html.
37. Departamentul pentru Ape, Păduri și Piscicultură, Directiva Cadru Strategia pentru mediul marini, Art. 11 Programul de monitoring, 19 august 2014.
38. T. Driesenaar, J. Kloe, M. B. Rivas, A. Stoffelen și V. Forneris, „PRODUCT USER MANUAL For Wind - Global Ocean L3 Wind,” Copernicus, 2018.
39. P. University, „The Princeton Ocean Model,” The Trustees of Princeton University, [Interactiv]. Available: http://www.ccpo.odu.edu/POMWEB/index.html. [Accesat 25 11 2018]

40. Mee, Laurence & Cooper, Philip & Kannen, Andreas & Gilbert, Alison & O'Higgins, Timothy & Mee, Laurence & Cooper, Philip & Gilbert, Alison & Higgins, Tim. (2015). Sustaining Europe's Seas as couple social-ecological systems. ECOLOGY AND SOCIETY. 20. 10.5751/ES-07143-200101.
41. PIHA HENNA EMILIA; HANKE Georg; GALGANI Francois; WERNER Stefanie; ALCARO Luigi; MATTIDI Marco; FLEET David; KAMIZOULIS George; MAES Thomas; OSTERBAAN Lex; THOMPSON Richard; VAN FRANEKER Jan Andries; MOUAT John; MEACLE Mary; CARROLL Chris; DETLOFF Kim Cornelius; KINSEY Sue; NILSSON Per; SHEAVLY Seba; SVÄRD Bo; VEIGA Joana Mira; MORISON Sarah; KATSANEVAKIS STYLIANOS MARIOS; LOPEZ-LOPEZ Lucia; PALATINUS Andreja; SCOULLOS Michael, (2011), Marine Litter: Technical Recommendations for the Implementation of MSFD Requirements, Publications Office of the European Union, ISBN: 978-92-79-21801-9 (print), 978-92-79-21802-6 (PDF).
42. Golumbeanu, Mariana & Nenciu, Magda & Galatchi, Madalina & Nita, Victor & Anton, E & Oros, Andra & Ioakeimidis, Christos & Belchior, Constança. (2017). Marine litter watch App as a tool for ecological education and awareness raising along the Romanian Black Sea coast. Journal of environmental protection and ecology. 18. 348-362.
43. Galgani, François & Hanke, Georg & Werner, Stefanie & L, Oosterbaan & Nilsson, Per & Fleet, David & Kinsey, Susan & RC, Thompson & Van Franeker, Jan & Vlachogianni, Thomais & Scoullos, Michael & Mira Veiga, Joana & Palatinus, Andreja & Matiddi, Marco & Maes, Thomas & Korpinen, Samuli & A, Budziak & H, Leslie & Gago, J. & G., Liebezeit. (2013). Guidance on Monitoring of Marine Litter in European Seas.

Annex

Tables regarding points from where waste was collected and labeled

Sector name	Coordinates WGS 84	
Vama Veche	43.747750	28.578500
	43.748583	28.578111
Saturn	43.833639	28.590694
	43.834556	28.590694
Tuzla	43.999139	28.662611
	44.000028	28.662417
Eforie	44.045222	28.645528
	44.046111	28.645250
Constanța	44.193139	28.655167
	44.194056	28.655111
Mamaia Nord	44.280000	28.621861
	44.280889	28.621806
Năvodari	44.309222	28.630250
	44.310056	28.630639
Corbu	44.366722	28.704278
	44.367556	28.704722
Ammos Blu Beach	44.267670	28.621585
Flora beach	44.229668	28.629573

	Location coastal characteristics Water flow code	Codul fluxului de apa	1	2	3	4	5	6	7
1	**Name**	Nume	Danube	Profile 1	Profile 2	Profile 3	Black Sea north sector Bottom trawl	Black Sea central sector Bottom trawl	Black Sea south sector Bottom trawl
	Type of shape	Tipul formei	-	-	-	-			
	Width	Latime (m)	500	2100	1250	2670	-	-	-
	GIS data - link to a file with metadata	Datele GIS - link catre un fishier cu metadate							
	Speed (m/s)	Viteza (m/s)	-	-	-	-	-	-	-
	Relative Velocity (m/s)	Viteza relativa (m/s)	1	0.24	0.19	0.15	-	-	-
	Category of the waste - % distribution	Categoria deseurilor - % Distributie	PE-62.07 PP-3.45 PET-3.45 PS-14.94 ABS-1.15 NYLON-PA-8.05 iPP/EPR-4.6 WOOL+PP-1.15 OTHER-1.15	-	-	-	Plastic-27 Metal-52 Textiles-19 Bottles-2	Plastic-21 Metal-19 Wood-60	Plastic-36 Metal-41 Textiles-15 Wood-8
	Size of the waste - %distribution	Marimea deseurilor - % Distributie	-	-	-	-	-	-	-

	Concentration of each type of waste	Concentratia fiecarui tip de deseuri	-	-	-	-	-	-	-
	Concentration based on size	Concentratiea bazata pe dimensiune	-	-	-	-	-	-	-
2	**Type of periodicity**	Tipul periodicitatii	Sezonier	Sezonier	Sezonier	Sezonier	Sezonier	Sezonier	Sezonier
	Character of periodicity	Caracterul periodicitatii	-	-	-	-	-	-	-
	Additional complex factor of periodicity	Factor aditional complex de periodicitate	-	-	-	-	-	-	-
	Exact time - time of the day, day, month, year	Timpul exact al zilei; ziua, luna, an	-	-	-	-	-	-	-

Danube River waste collection coordinates: 45°25'2.76"N

28° 2'6.67"E

Type and name of the waste	Tipul si numele deseului	Code of the waste (internal for project)	Size of the waste (cm)		
			< 2.5	> 2.5; <50	50>
Shopping Bags incl. pieces	Genti de cumpărături incl. bucăți	G3		x	

Food containers incl. fast food containers	Recipiente alimentare incl. Recipiente pentru alimente rapide	G10	x	
Other cosmetics bottles & containers	Alte sticle și recipiente cosmetice	G12	x	
Plastic caps and lids	Capacele și capacele din plastic	G20	x	
Plastic caps/lids drinks	Capacele / capacele de plastic băuturi	G21	x	
Plastic rings from bottle caps/lids	Inele din plastic din capace / capace din sticlă	G24	x	
Tobacco pouches / plastic cigarette box packaging	Pungi pentru tutun / ambalaje pentru cutii de țigări din plastic	G25	x	
Cigarette butts and filters	Mucuri și filtre de țigară	G27	x	
Pens and pen lids	Stilouri și capacuri pentru stilou	G28	x	
Chips packets/sweets wrappers	Ambalaje Chipsuri / ambalaje de dulciuri	G30	x	
Toys and party poppers	Jucării și obiecte de petrecere	G32	x	
Cutlery and trays	Tacâmuri și tăvi	G34	x	
Cover / packaging	Capac / ambalaj	G38	x	
Mussels nets, Oyster nets	Plase de midii, plase stridii	G45	x	
String and cord (diameter less than 1cm)	Sfoara și șnur (diametru mai mic de 1 cm)	G50	x	
Sheets, industrial packaging, plastic sheeting	Foi, ambalaje industriale, foi de plastic	G67	x	
Shoes/sandals	Pantofi / sandale	G71	x	
Foam packaging/insulation/polyurethane	Ambalare din spumă / izolație / poliuretan	G74	x	
Plastic pieces 0 -2.5 cm	Bucăți de plastic 0 -2,5 cm	G78	x	
Plastic pieces 2.5 cm > < 50cm	Bucăți de plastic 2,5 cm> <50 cm	G79	x	
Polystyrene pieces 0 -2.5 cm	Bucăți de polistiren 0 -2,5 cm	G81	x	
Polystyrene pieces 2.5 cm > < 50cm	Bucăți de polistiren 2,5 cm> <50cm	G82	x	
Polystyrene pieces > 50 cm	Bucăți de polistiren> 50 cm	G83		x
Plastic construction waste	Deșeuri de construcții din plastic	G89	x	

Plastic flower pots	Ghivece de flori din plastic	G90	x
Cotton bud sticks	Bete de Bumbac	G95	x
Syringes/needles	Seringi / ace	G99	x
Industrial pellets	Peleti industriali	G112	x
Other plastic/polystyrene items (identifiable)	Alte articole din plastic / polistiren (identificabile)	G124	x
Condoms (incl. packaging)	Prezervative (inclusiv ambalaje)	G133	x
Rope, string and nets	Frânghie, sfoară și plase	G142	x
Other textiles (incl. rags)	Alte materiale textile (inclusiv zdrențe)	G145	x
Cigarette packets	Pachete de țigări	G152	x
Paper fragments	Fragmente de hârtie	G156	x
Corks	Pluta	G159	x
Bottle caps, lids & pull tabs	Capacele sticlei, capacele și filele de tragere	G178	x
Bottles incl. pieces	Sticle incl. bucăți	G200	x
Paraffin/Wax	Parafina / Ceara	G213	x
Various rubbish (worked wood, metal parts)	Deșeuri diverse (lemn prelucrat, piese metalice)	G216	x

Ammos Blu Beach waste collection coordinates:44°16’13”N
28°37’33”E

Type and name of the waste	Tipul si numele deseului	Size of the waste (cm)

		Code of the waste (internal for project)	< 2.5	> 2.5; <50	50>
Polystyrene pieces 2.5 cm> <50 cm	Bucati polistiren 2,5 cm > < 50 cm	G82		1	
Plastic bottles > 0.5 l	Sticle plastic > 0.5 l	G8		1	
Bucatl plastic / polystyrene 2.5 cm> <50 cm	Bucatl plastic/polistiren 2,5 cm > < 50 cm	G76		1	
Plastic bottles <= 0.5 l	Sticle plastic <= 0.5 l	G7		1	
Fresh food (incl. Fast-food)	Recpiente alimente (incl. fast-food)	G10		1	
Small plastic bags e.g. freezer bags	Pungi de plastic mici ex. pungi de congelat	G4		2	
Pale and teaspoons to mix	Pale si lingurite de amestecat	G35		2	
Cutlery and plastic trays	Tacamuri si tavi plastic	G34		2	
Package of chips / sweets	Pachete chipsuri/arnbalaje dulciuri	G30		2	
Plastic bags (incl. Pieces)	Pungi plastic (incl. bucati)	G3		2	
Cigarette filters and filters	Mucuri si filtre de tigara	G27		3	
Plastic caps for plastic. bottles	Capace de plastic pt. sticle	G21		3	
Bottles (incl. Glass pieces)	Sticle (incl bucati sticla)	G200		6	

Flora Hotel waste collection coordinates: 44°13′25″N

28°37′21″E

Type and name of the waste	Tipul si numele deseului	Code of the waste (internal for project)	Size of the waste (cm)		
			< 2.5	> 2.5; <50	50>

Foam sponge	Burete spuma	G73	1
Jars including pieces	Borcane incl. bucati	G201	1
Twine and rope (diameter <1 cm)	Sfoara si franghie (diametru < 1 cm)	G500	1
Cutlery and plastic trays	Tacamuri si tavi plastic	G34	2
Lighters	Brichete	G26	2
Food Can	Conserve (alimente)	G176	2
Cans (drinks)	Doze (bauturi)	G175	3
Bottles (incl. Glass pieces)	Sticle (incl bucati sticla)	G200	3
Cigarette packages / plastic cigarette packaging	Pachete de tigari/ambalaj plastic tigari	G25	4
Glass or ceramic fragments> 2.5 cm	Fragmente sticla sau ceramica > 2.5 cm	G208	4
Straw and teaspoons to mix	Paie si lingurite de amestecat	G35	4
Other textiles (incl. Carpets)	Alte textile (incl. carpe)	G145	4
Pieces of polystyrene 2.5 cm> <50cm	Bucati polistiren 2.5 cm > < 50cm	G82	4
Other plastics / polystyrene objects	Alte obiecte din plastrc/polistiren	G124	5
Plastic bags (incl. Pieces)	Bucati plastic/polistiren 2.5 cm > < 50 cm	G3	8
Plastic / polystyrene pieces 2.5 cm> <50 cm	Pachete chipsuri/ambalaje dulciuri	G76	9
Packs of chips / sweets packaging	Sticle plastic > 0.5 l	G30	10
Plastic bottles> 0.5 l	Sticle plastic <= 0.5 l	G8	13
Cigarette filters and filters	Reciplente alimente (incl. fast-food)	G27	16
Plastic bottles <= 0.5 l	Pungi plastic (incl. bucati)	G7	20
Food containers (incl. Fast-food)	Pungi de plastic mici ex. pungi de congelat	G10	23
Small plastic bags e.g. freezer bags	Capace de plastic pt. sticle	G4	26

Plastic caps for plastic. bottles	Mucuri si filtre de tigara	G21	26

Vama Veche waste collection coordinates: 43°46′15″N
28°35′26″E

Type and name of the waste	Tipul si numele deseului	Code of the waste (internal for project)	Size of the waste (cm)		
			< 2.5	> 2.5; <50	50>
Light bulbs	Becuri	G202		1	
Cork plugs	Dopuri de pluta	G159		1	
Jars including pieces	Borcane incl. bucati	G201		1	
Fishing gear (weights, leads, baits)	Articole de pescuit (greutati, plumbi, momeli)	G172		1	
Food cans	Conserve (alimente)	G176		1	
Cardboard / tetra pack packaging (other)	Ambalaje carton/tetrapack (altele)	G151		1	
Bottles and containers of motor oil <50 cm	Sticle si recipienti de ulei motor <50 cm	G14		1	
Rubber boots	Cizme cauciuc	G127		1	
Spray aerosol	Sprayuri aerosol	G174		2	
Packaging cardboard / tetra pack milk	Ambalaje carton/tetrapack lapte	G150		2	
Wheels	Roti	G130		5	
Bottle caps and key cans	Capace sticla si chei doze	G178		5	
Flip flops	Slapi	G102		7	
Lighters	Brichete	G26		9	
Other bottles and barrels containers	Alte sticle si recipienti butoaie	G13		9	
Glasses and plastic caps	Pahare si capace plastic	G33		14	
Bottles and cosmetic containers for the beach	Sticle si recipienti cosmetice pentru plaja	G11		14	
Mesh nets and pieces <50 cm	Plase si bucati de plasa < 50 cm	G53		18	

Packaging / plastic rings for cans	Ambalaje/inele plastic pentru doze	G1	19
Mussels, oysters	Plase de midii, stridii	G30	23
Cutlery and plastic trays	Tacamuri si tavi plastic	G34	23
Foam sponge	Burete spuma	G73	32
Cigarette packs / plastic cigarette packaging	Pachete de tigari/ambalaj plastic tigari	G25	35
Other textiles (incl. Carpets)	Alte textile (incl. carpe)	G145	40
Polystyrene pieces 2.5 cm> <50cm	Bucati polistiren 2.5 cm > < 50cm	G82	41
Straw and teaspoons to mix	Paie si lingurite de amestecat	G35	48
Glass or ceramic fragments> 2.5 cm	Fragmente sticla sau ceramica > 2.5 cm	G208	52
Packs of chips / sweets packaging	Pachete chipsuri/ambalaje dulciuri	G30	52
Bottles (incl. Pieces of glass)	Sticle (incl bucati sticla)	G200	66
Other plastic / polystyrene items	Alte obiecte din plastic/polistiren	G124	74
Twine and ropes (diameter <1 cm)	Sfoara si franghie (diametru < 1 cm)	G500	86
Plastic bottles <= 0.5 l	Sticle plastic <= 0.5 l	G7	100
Food containers (incl. Fast-food)	G10 Reciplente alimente (incl. fast-food)	G10	101
Cans (drinks)	Doze (bauturi)	G175	104
Plastic bags (incl. Pieces)	Pungi plastic (incl. bucati)	G3	121
Small plastic bags e.g. freezer bags	Pungi de plastic mici ex. pungi de congelat	G4	121
Plastic caps for bottles	Capace de plastic pt. sticle	G21	145
Plastic bottles > 0.5 l	Sticle plastic > 0.5 l	G8	238
Cigarette filters	Mucuri si filtre de tigara	G27	423